12-2021

The Effects of Audio/Visual Stimulation and Virtual Reality to Increase the Rate of Retention in First Semester Freshmen Graphic Communications Students

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THE EFFECTS OF AUDIO/VISUAL STIMULATION AND VIRTUAL REALITY TO INCREASE THE RATE OF RETENTION IN FIRST SEMESTER FRESHMEN GRAPHIC COMMUNICATIONS STUDENTS

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Graphic Communications

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by
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December 2021

Accepted by:
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ABSTRACT

Gibson, L. Hanna, The Effects of Audio/ Visual Stimulation and Virtual Reality to Increase the Rate of Retention in First Semester Freshmen Graphic Communications Students, Master of Science (Graphic Communications), December 2021, Clemson University, Clemson, South Carolina.

In March of 2020, the world entered the COVID-19 pandemic, leaving educators to answer the question, "how do we teach in a virtual environment?". This was especially difficult for deeply rooted STEM programs such as Graphic Communications at Clemson University. This research aims to analyze multiple methods of virtual teaching for connection between enhanced retention rates.

This thesis attempts to solve the problem facing global STEM educators when they are attempting to prepare material for students in a virtual environment. This is achieved by presenting them with how different methodologies impact the retention rate on freshmen level students enrolled in the Graphic Communications program at Clemson University. The study divided students into three groups, all receiving a different instructional method, and then assessed their retention on the content area of flexography press. This area is traditionally delivered in a hands-on approach.

This research study provided data that demonstrates that the implementation of virtual reality software increases the rate of retention for STEM students with no previous knowledge of a flexography press. However, the biggest takeaway is that virtual reality software enhanced their ability to retain the functionality of parts much better than those of their peers who received other teaching methodologies. This research can be applied to

future studies in this area by assessing a larger group of students and other content areas. This research could be furthered by expanding it to include other groups of STEM students such as engineering to validate if virtual reality is a factor for increased retention rates across all STEM students.

DEDICATION

This research is dedicated to my parents, without whom I would not be here fulfilling this degree today. Thank you for instilling the belief in me that I can do whatever I set my mind to, including pursuing a degree full-time while holding down a full-time job. Thank you for the late-night phone calls, the interest in my research area, and the weekly dinner when I needed a break.

Thank you for instilling the value of education in me, and the work ethic to pursue hard things with unwavering determination.

As I pursued this degree dad was diagnosed with cancer and I have watched both of you fight with extreme courage and determination. The strength I see in both of you has sustained me through the difficult times of this past season.

ACKNOWLEDGMENTS

I cannot start this thesis without acknowledging my mentor and graduate chair, Dr. Woolbright. Without your guidance and support I question if I would be writing this research today. Your mentorship and encouragement has been one of the driving forces in my career throughout this endeavor.

I am extremely grateful to the faculty and staff I work with for supporting me as I pursued this degree and entered your classrooms as a student. Learning from each of you has been a great privilege for me and my knowledge of the Graphic Communications industry has been forever impacted by your knowledge and willingness to teach.

A huge thank you to my committee. Taking on a graduate committee seat during a pandemic is not lost on me and I understand communication on research was greatly strained during this. I am so thankful to work with and learn from each of you and your role in this research is something I am thankful for. I greatly feel like this endeavor has made me better at my job and a better asset to this department.

Lastly, thank you to Dr. Chang and Mrs. Fox who were continually my cheerleaders through this process. You both celebrated every victory of mine throughout graduate school and my research. Your attitudes, support, and enthusiasm gave me continued strength as I pursued this degree.

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INTRODUCTION

"As a profession, education is responding powerfully to the notion of virtual reality curriculum. Educators seem to have an instant – and almost visceral understanding of the learning potential that well-designed, virtual experiences could offer students" (Helsel, 1992). The COVID-19 pandemic forced educators to rethink how to educate students in a virtual environment on a global scale. The pandemic posed substantially larger issues for STEM programs, emphasizing hands-on learning in a laboratory setting. One of these programs is Graphic Communications, located at Clemson University. The scope of this study is to determine if virtual reality exercises increased retention and understanding of parts of a flexography press in freshmen students at Clemson University.

There are multiple definitions of what virtual reality means. In some cases, a virtual environment requires glasses and gloves to participate in the virtual reality. On the other hand, some realities are created, and the user has almost zero control of the objects and their placement within the virtual reality. For this study, the definition of virtual reality will be defined as "a highly interactive, computer-based, multimedia environment in which the user becomes a participant with the computer in a "virtually real" world" (Pantelidis, 1993).

LITERATURE REVIEW

An article written by Alex Joffe, explains "like the Sputnik satellite launch in 1957, the coronavirus pandemic is an opportunity to transform science and technology education" (Joffe, 2020). The Covid-19 pandemic caused all educators to rethink what is taught and how the content is taught. The impact of this is felt significantly within the STEM areas such as Graphic communications. The shock of the pandemic for educators "should be the realization of how poorly we understand the science and technologies that underpin the 21st century, even as we rely on them wholly" (Joffe,2020). Such technologies like a flexography press are taught in the same manner today as they were twenty years ago. Even in STEM fields, many educators tend to rely heavily on traditional hands-on learning that was removed from classrooms during the Covid-19 pandemic. The effects of this were seen in varying ways in higher education classrooms. The removal of standardized systems left educators with individual questions on how to continue forward. This fundamental gap in teaching that occurred as students were removed from classrooms is the underlying force that sparked this research study. Expanding on this is an article titled The Graphic Communication Curriculum for the Next Millennium, written by Anthony Faiola. This article expands upon the recent changes in the Graphic Communications industry that has left many industry members feeling estranged from the once common vocational trade.

The article explains, "it is critical that GC educators address a broad range of important issues brought about by technology" (Faiola,1999). One new and emerging technology that is important for Graphic Communications students to become familiar with is the integration of Virtual Reality as a means of learning and training software within the industry. It still looks pretty cutting edge now; however, ten years from now, this will be standard technology, and students need to be exposed not only to the technology but also to the potential limitations. Faiola believes that one of the ways to develop strong critical thinking students is to promote collaboration between academia and the industry through self-funded research centers housed at the university. The study that is the focus of this paper was conducted in cooperation with the Sonoco Institute at Clemson University as they developed the Virtual Reality pressroom. "Providing students with educational-industrial collaboration in research and development has the potential to increase their competency" (Faiola, 1999). One of the primary focuses of this study is to see if the exposure and implementation of new cutting-edge software would increase student retention, connections, and competency, as Faiola outlined as a potential factor for student success in the industry.

Moving forward to look at studies previously completed that place students into virtual reality environments is found in an article written by Pantedlidis. One of the first reported educational research studies involving virtual reality was titled the Creative Technologies Project conducted by Mark Merickel in 1990. One of the first educational virtual reality studies is only thirty-one years old. There is so much left to be discovered about the potential benefits of this technological addition in the classroom, which is still uncharted when compared to other educational methods and practices. The author state, "the conclusion of the study was that cyberspace is highly promising and deserves extensive development as an instructional tool" (Pantedelis,1993). Earlier in the article, the author establishes the definition of cyberspace as "a highly interactive, computer-based, multimedia environment in which the user becomes a participant with the computer in a virtually real world" (Pantedelis,1993). This is a definition that aligns with virtual reality-based software like the VR flexography web-based software used in the scope of this study as it does not involve the addition of goggles or gloves to enter the virtual world. It simply requires access to the internet and then engages the user through various learning techniques as they move through the virtual room.

The next article was written by Howard Gardner, where he outlines his theory of multiple intelligences in 1987. He spends the first few pages of the paper speaking about the earlier measurement areas of intelligences and how he feels intelligence is quantitive, as seen in a QT test, but it is also qualitative. Howard aligns himself with the earlier workings of Piaget in that he also "believes all aspects of intellect are connected" (Gardner, 1987). What Gardner found is that there are multiple 'kinds of minds' as he refers to it in his earlier works and then proceeds to change the name later to multiple intelligences. To expand on what he means by intelligences, he compares dancers, athletes, shaman psychoanalysts, and politicians. He says that they are "roles of value which spread across different societies and are not necessarily traits that would pick up on a traditional intelligence test," even though we would all agree these roles require a certain degree and level of intelligence. He finally concludes that the definition of intelligence is "an ability to solve a problem or to fashion a product which is valued in one or more cultural settings" (Gardner, 1987). This is the definition of intelligence that will be applied throughout this study as well. After conducting extensive research, Gardner determines that there are seven different intelligences that different human beings can pose. These seven intelligences are linguistic, logical/mathematical, musical, interpersonal, intrapersonal, spatial, and bodily kinesthetic intelligence. Gardner explains that he believes people place too much value on just linguistic and mathematical intelligences in our society, as seen in student IQ tests and performance evaluations. Bodily kinesthetic is the most crucial intelligence for the scope of this study as STEM students tend to fall into this level of intelligence. Gardner explains that bodily kinesthetic intelligence refers to "the ability to use your whole body or parts of your body like your hand to solve a problem or fashion a product" (Gardner, 1987). This is referred to now as 'hands-on' learners or those who learn by physically doing. Most Graphic Communications students fall under this umbrella of intelligence and learning style.

Gardner continues through this article to explain how his theory of multiple intelligences is different from other studies and theories about intelligence. He concludes that it is different based on three factors: it is based on biological analysis, takes cultural implications, and is not horizontal across content. He claims that all other theories draw on the results of tests rather than biological analysis and that the 'natural mind' is organized to inherently do seven things very well, hence the seven intelligences. In addition, Gardner explains that different cultures value different skills and abilities. He explains, "it is quite possible somebody could break the books on an IQ test, and score 287, but wouldn't have any ability that is useful within their own culture" (Gardner, 1987). Therefore, high measured intelligence is not beneficial if it is not deemed valuable by the person's culture. Lastly, Gardner rebukes the notion that basic horizontal laws of learning cut across all content. His theory is vertical in that the mind is organized in terms of content. Gardner finishes his article by turning to the educational implications of this theory. He states that "we can use multiple intelligence theory as a way of analyzing educational encounters in which a person is learning something, or is trying to, in school, watching the television, reading a book, or simply walking around the hall (Gardner, 1987). By recognizing the different levels and types of intelligences, we give validity to nonlinguistic and mathematical learning and encourage them to strengthen the areas in which they are inclined to exceed. For Graphic Communications students, this could mean more kinesthetic projects and the ability to connect learning events together using a cause-effect relationship to comprehend the functionality of processes.

The next article is an interesting case study published in the International Forum of Educational Technology & Society written by Michael Holly in 2021 that looks at Designing virtual reality learning and educational experiments. This article was published as I was trying to make sense of the data I collected in Fall 2020 and allowed me to draw some parallels by looking at the case study for reference and findings. The study is focused on science, technology, engineering, and mathematics (STEM) students and explains that simulations are a valuable tool to support conceptual understanding by visualizing the process. The subject matter at hand in this study is physics, which often looks at formulas and values that seem invisible without simulation. The study uses 26 teachers and 59 students in different schools and training institutions. The article explains, "traditional teaching methods present solutions and concepts, but they fail to teach how to solve problems" (Holly, 2021). In this context, the word traditional means a pedagogical style that relies heavily on lectures delivered by an instructor to students and a formalized assessment of learning such as an examination or a test. This teaching style does not lend itself to kinesthetic or connective learning for STEM students, including Graphic Communications Students. The case study dives further in explaining that active learning is preferred and that lab settings of any form have unique advantages for students; however, "virtual laboratories enable expandable experiments, multiple access and visual representation of unseen phenomena with minimal potential for the occurrence of dangerous situations" (Holly, 2021). This is not to say that virtual laboratories should replace in-person labs. However, it demonstrates that virtual labs provide a unique set of conditions in which learning can occur. One of the takeaways from this study was that virtual reality lab settings could be very cost-effective for materials and overhead while providing the advantage of being accessible from anywhere. Therefore, labs could turn into take home learning for reinforcement. After conducting their study, they had both students and teachers rate the experience in terms of immersion, engagement, and ease of use. Both students and teachers had 9/10 ratings for the software even though there were some slight difficulties to begin with. In the end, the study found out that students have particular needs in a virtual environment and teachers need to structure lab experiments so that students can ease into the process. The plan for this case study is to serve to help with the funding of VR integration in the area where the research was done as the results were favorable and most of the world of education is beginning to rethink traditional in person normative given the COVID 19 pandemic that educators recently faced.

Understanding Multiple Intelligences is essential. However, knowledge without application is unusable. The article By Barry Thompson, Intelligent Teaching: using the theory of multiple intelligence in the inquiry classroom, dives deeper into the application methods utilized within the multiple levels of intelligences for classroom learning. Thompson views the area of student aptitude in multiple intelligences to identify the methods through which students are gifted. He explains, "some may have a gifted aptitude for the bodily/kinesthetic intelligence but not be quite as gifted in other intelligence forms, such as visual/spatial or verbal/linguistic." (Thompson, 2002). When we force these students to continually learn in perform in classrooms that are taught orally and with the use of only visual aids, we neglect their level of intelligence. We can often time damage a student's confidence in a particular area of study. Thompson continues to say, "many of these activities can be mimicked through new scientific methods of learning and experimentation" (Thompson, 2002). While this article was written in 2002, and I understand that he is not referring to VR specifically, he does seem to be convinced that kinesthetic learners can benefit through the new uses of science and technology to create these seemingly hands-on experiments artificially and when we neglect to teach to students capabilities instead of disadvantages we hold them back from their full potential in the content are.

Looking forward, educators and scientists have been researching and debating how VR can play a role in both education and industry training for almost two decades. An article written in 1995 by Joseph Psotka dives into this topic further. Psotka explains, "what distinguishes VR from all preceding technology is the sense of immediacy and control created by immersion" (Psotka, 1995). Unlike watching a tutorial or instructional video, the user or student must physically act and participate in VR, creating a sense of immediacy for whatever task is at hand. It will not form a result without user interaction. The article outlines what VR is and the different types of VR that are currently being used. Later in the article, the author dives into the benefits of the immersion experience and engagement level. He states, "parts of this engagement come from the thrill of new technologies, but there is a more enduring and valuable component as well: VR is an empowerment technique that opens many new paths for learning" (Psotka, 1995). By giving students a VR assignment, you essentially place them in control of the assignment and all the control variables. It allows for students to dictate how they feel they should interact in the virtual environment and the freedom to decide how to go about the project without fear of safety repercussions. This type of communication between user and interface is one of the unique factors that set VR apart. It serves as a communication device between mental representation and symbolic form. This creates new conceptual worlds for the user. The most direct and compelling benefit is that VR and cognitive interpretation causes a reduction in conceptual load because it simplifies perception for the user. It tends to block out all of the background and excess distractions that typically happen in real life. For the scope of my research, this looks like a silent and personal press room that allows a student the time, space, and freedom to make their own decisions. This reduction in cognitive load also enables students to have more resources to carry out problem solving and critical thinking through other issues. Therefore, it is not unreasonable to say that a distracted student traditionally could learn and perform better in this simulated virtual environment altogether.

An article written in 1993 by Veronia Pantelidis goes into detail about Virtual Reality and emerging technology. The author begins by stating, "virtual reality has the potential to be a powerful new tool in the classroom" (Pantelidis, 1993). This article was written almost two decades ago, yet there was already discussion about the potential for VR to become an educational tool. The article explains that for the scope of the report, the term virtual reality will apply to artificial reality, cyberspace, and telepresence. These are now broken down into more specific categories. The difference between cyberspace and telepresence is the equipment required to 'enter' the virtual realm. Telepresence requires gloves and head mount displays, while cyberspace only requires a desktop and a mouse. Currently, we use these terms interchangeably. The article briefly discusses the history of virtual reality developments and finally dives into why virtual reality is a good fit for education. "Audiovisual media provide windows through which the real world can be viewed from the classroom. Virtual reality can extend the classroom via new windows, into other realities" (Pantelidis, 1993). Unlike tutorials or traditional instruction, virtual reality puts the student into an immersive learning environment and makes the experience transferable to their own experiences. Most students are exposed to tutorials where educators or industry shows examples in their environment, leaving them passive observers instead of active participants like in virtual reality. In this way, the active component can be a significant motivating factor for students as it provides a sense of interaction and individualization for the student in the environment. This type of learning tool forces each student to step out of the observer role and into that of the experimental conductor. "Mark Merickel conducted a study to determine whether a relationship exists between perceived realism of computer graphic images and the ability of children to solve spatially related problems" (Pantelidis, 1993). This study concluded that students could better solve problems and mimic the behavior in virtual reality settings that they perceive to be realistic. Unrealistic virtual reality settings tended to receive the result of a video game interaction instead of a tangible experience replication. The article concludes by explaining the importance of embracing these new emerging technologies that allow students to have individuality and provide motivation. The author further explains that these virtual scenarios are the future for self-guided learning and exploration for the next generation.

The pandemic presented a unique set of circumstances and challenges for higher education institutions. Especially those universities that are primarily based as brick-and-mortar learning environments like Clemson University. An article College in the Time of

Coronavirus Challenges Facing American Higher Education written by Andrew Kelly, addresses these issues head on as they are different than the challenges facing k-12 state funded institutions. Kelly starts off the article by reflecting on pandemics in the past, saying, "past plagues have given rise to some of the most important works of literature and science" (Kelly, 2020). This reframes the narrative of 'just getting by' in the time of a pandemic to a mindset of exploration and invention that could have lasting impacts decades after the end of the COVID-19 pandemic. With that in mind, the research and approaches to science, learning, and education during this time could be a shift in thinking that does not go away after the pandemic. This is the aim of starting a research endeavor such as this one in virtual reality learning software. Kelly continues to point out one of the fundamental issues institutions faced, "it is hard to overstate how fundamental a change this was for traditional institutions, which were specifically designed to bring students, teachers, researchers, and other community members in close proximity" (Kelly, 2020). These are inherently the core issues that universities faced over the course of distance learning. The educational structure that professors, staff, and students previously adhered to relied on the stability that they were going to have proximity and access to resources and people. For STEM majors, these issues were of higher value as lab time and hands-on learning play a primary and integral role in the educational process. Many professors in STEM academic disciplines never taught or conducted an online lecture, let alone an entire course, before they were abruptly shifted to online only learning environments in March 2020. As many students struggled to excel in this learning environment, many professors had to reevaluate how they taught their material and found themselves 'reinventing the wheel' for a profession they had spent decades working in. However, studies have shown that many faculty members altered assignments, lowered expectations, or even granted pass/fail during the initial semester. "An April survey of 3000 continuing students by the education technology firm Top Hat found that most students felt that emergency online instruction was unengaging (70 percent) and inferior to their typical face to face experience (68 percent)" (Kelly, 2020).

This statistic demonstrates the immediate need for new emerging technologies like virtual reality integration to prepare educators for online instruction that can engage students and provide added value for kinesthetic STEM learners. Higher education was unprepared for the immediate collapse of traditional learning, and as such, faculty, staff, and students suffered the consequences. However, the purpose of research such as my own is to provide opportunities for education on the tools that are supplemental when in person learning is unavailable. Kelly recognizes that even though many institutions have reopened for traditional learning, the lingering impacts of COVID-19 can be felt, and many of these tactics for distance learning are needed. "All institutions should be working from the premise that they will have a case of COVID-19 on campus during the academic year" (Kelly, 2020). This was the advice given by the U.S. executive director for American Public Health before the beginning of the Fall 2021 semester. This has proven to be the case throughout universities all over the country. This leaves many professors in an environment where within one particular course, they could have: positive students, students in quarantine, traditional students, asymptomatic students who would like to view online, and students who would like to stay distance learning due to medical conditions. Given circumstances such as these, many institutions are still having to find the happy medium between in person traditional and online learning when needed for students. This is a time when virtual reality press work could be a great option. It would allow students to remain on the same assignments and bridge some gaps between these different scenarios. This is not to say that any one distance learning technique that emerges will replace the value of traditional learning. However, the hope is that they will create a more engaging virtual environment when necessary.

Throughout the pandemic, the terms' distance learning' and 'e-learning' have been used interchangeably, but they are not inherently the same at all. Looking back to an article written in 2005 by Sarah Guri-Rosenblit, she explains that there are different definitions, but there are various applications and trends for the learning styles. The term distance learning "adopts the opposite course of a campus-based university. Instead of assembling students from dispersed locations in one place, it reaches out to student wherever they live or wish to study" (Guri-Rosenblit, 2005). The model of distance learning is to deliver the course in a way where the students and professor are separated not only by space but also by time. This has recently been referred to as 'asynchronous learning.' Distance learning is a method in which most education occurs through homework with occasional class work instead of the traditional model of primarily class work with periodic homework. In addition, distance learning is education where the classroom sessions are not the primary means of information dissemination. This is different from how the author defines what e-learning is "relates to the use of electronic media for a variety of learning purposes that range from add-on functions in conventional classrooms to full substitution for face-to-face meeting" (Guri- Rosenblit, 2005). E-learning within itself is using new technology to reinforce ideas, coursework, collaboration, or exploration. Contrary to the misconception, "distance is not a defining characteristic of e-learning" (Guri-Rosenblit, 2005). Over the past eighteen months, these terms have been used in a way where many education professionals have failed to realize that e-learning can continue to provide added benefits for them and their students in a traditional classroom setting. This is not to say that the usage of information communication technologies does not help facilitate distance learning, but to emphasize that they are within themselves different educational methods.

The flexographic virtual reality software falls under the category of e-learning. It is intended to be used as a classroom aid even if the class meets face to face for in person traditional coursework. However, it can be relied on much heavier in the event of distance learning but does provide value regardless of teaching method. One advantage to e-learning is that "unlike distance learning, e-learning is used by all types of students on all educational levels" (Guri-Rosenblit, 2005). Kindergarten may use a web-based computer game as a form of e-learning as it can be tailored to each skill level of the pupil, provide a self-guided activity, and engage the pupil in new and exciting ways. This could be used for sight words and recognition and does not replace the role of the classroom work provided by the teacher, but it does allow for individualized instruction and self-engagement to reinforce learning. This idea continues through to post-secondary education. Students have different needs, time constraints, learning styles, and engagement needs. Using e-learning techniques still helps to solve those issues. "MIT is a leading institution in ICT (information communication technology) applications. It currently runs nearly forty projects related to various uses of the new technologies" (Guri-Rosenblit, 2005). However, the president of MIT openly stated that their essential learning style would be gathering students and faculty together for traditional learning with the usage of these technology applications to reinforce learning. This is the goal for the virtual reality simulation I discuss in this research. This application should not be used as distance learning but rather as e-learning. It is an available technology that allows for self-guided concepts and skills and increases engagement regardless of meeting style. The fact that this research stemmed from necessity during a pandemic that demanded distance learning should not dismiss that the application is a variation of e-learning that can be beneficial in all classroom environments.

There is still heavy debate on how to evaluate education and psychological studies in research. An article that dives into the topic of statistical significance was written in 1993 by James P. Shaver. At the beginning of the article, the author explains what statistical significance by saying, "at its very simplest is the hybrid hypothesis-testing model dominant in social science research, a procedure for determining how likely a result is assuming a null hypothesis to be true" (Shaver, 1993). This can be simplified even further in that it is a procedure for determining the probability of a particular result. While many factors play into this determination, one of those is sample size which varies significantly in education studies such as this one. However, if the sample size for which a study was collected is small, the statistical significance will be low due to the sample size. This is not to say that the study is not credible or that it would not be significant when applied to a larger sample size. However, it is a factor when studies have a smaller sample size and begin to determine the probability and results of the study. This is one of the reasons that there are so many arguments against using this in the areas of education and psychology. Throughout this discussion, one of the emerging reasons this is disputed is the lack of emphasis on randomization among sample size and the reliance on sample size alone. Shaver states, "some studies are random in their sampling but not random in assignment to treatment, whereas others are random in assignment but craft the sampling to match a certain population targeted" (Shaver, 1993). The fact that randomization is used ambiguously throughout studies and then uses those different definitions to determine significant changes in how it can be viewed across other research areas. In this study, random assignment occurred, but the population chosen was to mock that of the graphic communications industry and thus targeted graphic communications students. In addition, during the study, the treatment groups, and assignments were assigned at random and not based on any determining factors. Shaver discusses that "a test of statistical significance used without randomization, then, does not yield valid information about the probability of a result under the null hypothesis" (Shaver, 1993). Therefore, in fields such as education, the numerical value of statistical significance is less important than understanding the concept of the study and how the findings could be applied to larger groups. Throughout the cycle of repeating these studies, the sample size will grow, and the numerical value will be reliable.

While most of the educational theories and ideologies used in this study are long established, there is one that is more recent as the emergence of technology. This is referred to as the Engagement Theory. This theory emerged when educators began having experiences in teaching in electronic and distance education environments. I believe that any educator who worked through the COVID-19 pandemic would agree that distance learning and new technologies require a different framework entirely to continue with the engagement that is naturally encouraged in a classroom or laboratory environment. In outlining this theory, Kearsley explains, "the fundamental idea underlying engagement theory is that students must be meaningfully engaged in learning activities through interaction with others and worthwhile tasks" (Kearsley, 1998). This type of learning can occur without the usage of technology. However, in distance learning, the addition of technology can enhance engagement that is otherwise difficult to facilitate. This theory does draw from existing frameworks like the constructivist approach, situated learning theory, and adult learning. In outlining the basic principles, the author explains, "engaged learning means that all student activities involved active cognitive processes such as creating, problem-solving, decision-making, and evaluation" (Kearsley, 1998). However, these activities must be relevant and meaningful, which will promote student motivation to complete the tasks. Past studies have shown that if students do not find the work they are doing meaningful and worthwhile, they will be less likely to have intrinsic motivation to complete the course and be engaged. Later in the article, the author references a previous study that concluded: "that the virtual classroom environment resulted in better mastery of course materials and student satisfaction when paired with technology as compared to traditional classroom experiences" (Kearsley, 1998). While distance learning is not ideal for all course material and some content is better suited for this learning environment, it is crucial to understand that student mastery can occur in virtual classrooms when technology is leveraged correctly. The article wraps up by noting that engagement theory is not necessarily new in the emergence of the ideas. However, it takes pieces of past theories of learning and synthesizes them under the new umbrella of emerging virtual classrooms and technology access. The article concludes by saying, "engagement theory represents a new paradigm for learning and teaching in the information age, emphasizing the positive role that technology can play in human interaction and evolution" (Kearsley, 1998). This theory is not aimed to replace human interaction with technology. Arguably, no technology will ever be able to fill that hole. However, there is a space where some of the gaps created by virtual or distance learning can be bridged together through technology usage.

In addition, when learning is referred to, there are often two types of information tested for after instruction is given. These two areas fall into recognition/recall and application. For the scope of this study, both are looked at as the labeling of the diagram is considered recognition/recall. In contrast, the extra credit that attempted functionality of each piece falls under the category of application. A study presented by two Australian authors studies the difference between these two types of questions and learning from computer based instructional tasks. The test was comprised of 84 students, 51% female and 49% male, with over six different ethnicities represented. Forty-four students received static-plus-text, and 40 worked on an interrelated assignment. Static-plus-text "contained a basic static diagram of the human brain with labeling and color coding. All learned information was presented as written text only" (Spencer, Pillay, 2021).

In comparison, an interrelated format is "an interactive diagram that changed based on student interaction to reveal more information about the part of the brain and the functionality" (Spencer, 2021). Once both groups completed the instructional assignments, they were assessed on both recall/recognition and learned application. For most students' application is considered the goal of learning as it demonstrates a mastery of the content matter, whereas "recognition is theorized as a single process, which does not require generation of a full response" (Spencer, 2021). The static method was the traditional paper and pen method, whereas the interrelated engaged the usage of audiovisual digital learning requiring active learning on the part of the student. The author argues that "computer-based instruction is an effective form of instruction because it produces high student outcomes of achievement in short periods of time" (Spencer, 2021). This claim is supported by the findings of this study in which the interrelated performed at a much higher level than the static group did on both recall and application. The achievement gap was statistically significant at the .05 level. The study concludes by explaining that the interrelated group's design and element of interaction are what they attribute the high success outcomes too. Although the information displayed to each student was the same, the transition to active learning and the increased level of engagement required by the design of the interrelated group yielded overall better results in every category.

An analysis of student satisfaction with distance learning published in 2010 revealed that "distance education does not diminish the level of student satisfaction when compared to traditional face-to-face methods of instruction" (Allen, Bourhis, Burrell, Mabry, 2010). It is reasonable to infer that student satisfaction would still be on level with traditional methods. However, there were distinct differences that students reported to be factors that contributed to satisfaction or dissatisfaction. "Students with more computer experience were more likely to use the online resources" (Allen, 2010). During the pandemic, the students in higher education settings had even more technology exposure than those who were studied a decade earlier. Therefore, it is inferable that these students were more prepared for the transition to online learning. However, the educators were caught in what was referred to as the technology gap. The abrupt shift to distance learning during the pandemic struggled to keep up with the technology demands needed. It was found that educators and administrators who did not have prior knowledge of new technologies reported feeling overwhelmed and anxious, which proceeded to get worse as negative results or poor performance. One of the reasons that students reported they felt satisfied by distance learning is that "videotapes can be played at the convenience of the student and replayed to make images and explanations clear" (Allen, 2010). For instructors who approached distance learning through recorded video instruction, this allowed students advantages. The ability to replay videos during assignments and do it at their own pace allowed for individualized instruction on a large scale for the students. In addition, students felt less anxious when participating in class while in their own environment. This study was conducted by reviewing over 450 sources and points of data. This type of metadata evaluation allows for a broad sample size and increased accuracy of reported results. Overall, video and distance learning had a "+.547 positive correlation when compared to traditional instruction" (Allen, 2010). This is important to understand as it impacts the scope of this study by determining student reactions to distance learning and technology enhanced techniques. The students overall enjoy lecture-based distance learning and, based on this study, would positively respond if there were more opportunities added in education directed in this manner.

Building on this, a study in 2011 looked at the effectiveness of visual aids in teaching and learning at the university level. Audiovisual aids are defined as "those devices which are used in classrooms to encourage teaching learning process while making it easier and interesting" (Rasul, Bukhsh, Batool, 2011). Technological devices have the most significant impact on the dissemination of knowledge and informative systems. Audiovisual aids increase the individual experience and make it more relatable for each user. The article explains that for every student or major, there will inherently be more complex tasks to master where the teacher will need to give students additional ways to grasp information. This is where audiovisual tools can step in and be a supplemental tool. This study was a five-point rating scale questionnaire sent out to 150 students and 50 teachers through random sampling from a higher education institution. "The scale 1-5 correlated to strongly disagree to strongly agree. The mean score was 3.0 for each category and the results were compared to this bar" (Rasul, p.79). Students had an overwhelmingly positive reaction to the audiovisual addition, which reinforces the previous study's findings. The average student scores for questions referencing comprehension, ease of use, and effectiveness were 4.30-4.47 out of 5. However, educators' responses were on the lower end of the mean value the average for them ranged between 2.8-3.34. Once again demonstrating there is a gap in distance learning between educator feeling and interaction versus students' feelings and excitement. The authors stated that the intention of audiovisual aids was explained to all participants as an additional enhancement where students felt it reinforced learning and teachers felt it was confusing and unclear.

Moving forward to another article titled The Effect of Technology on a Student's Motivation and Knowledge Retention, published in 2012, analyzed how "motivation and retention are affected by technology-based projects" (Chernobilsky, Granito, 2012). The participants of the study were 102 students in a world history course. While the course content is not related to STEM, the findings of this study and how technology impacted motivation are still crucial in understanding student feeling toward technology and technology-based projects. The sample size of the study encompassed 50 boys and 52 girls across five ethnicities. "The students in the study were split into three groups: experiment group A, experiment group B, and a control group" (Granito, 2012). This is a similar setup to this study in the way that the students were grouped and received individualized instruction while one group was a control group. The students in this experiment took a pretest at the beginning of the study before instruction was received. The purpose of this was identical to my own study in that there was a defined baseline of knowledge set, and a post-test was conducted at the end of the unit. This post-test was identical to the pretest and was used to collect quantitative data. "Group A completed the two projects in a computer lab. Experiment group B had a choice of whether to use technology or not. Finally, the control group did all their work in the classroom without the use of technology" (Granito, 2012). There were ten days between the instruction and the post-test. The results of this study had a p-value that was significant in scores. The group who had a choice was slightly higher than the other groups. It was then compiled with qualitative data that revealed that computer-based projects were very successful for students who have an interest in technology. Contrastingly, students who fell in a lower social-economic group and did not grow up with access to technology found that the computer-based projects were confusing and preferred traditional instruction. The student demographic that was tested during my study all had access to their own laptops and all technology. Therefore, it is reasonable to assume that their level of comfort with technology is high.

An article that moves deeper into the use of information communication technologies in education was written by Mbodila and Kikunga, who focus primarily on a computer science department and their heavy research interest in STEM students. This article first presents that "in the 21st century understand education needs is more important than ever. That is why it is vital for educators to use methods or techniques that will enable learners to use their knowledge efficiently to solve problems in their daily lives" (Mbodilia, Kikunga, 2012). All teaching and learning in stem disciplines aim to train and condition students into a new way of thinking that creates problem solving students. The implementation of ICT's must be done repeatedly to see the intended outcomes and most issues that professors have with the implementation of all new communication technology because it produces immediate problems. However, these are reduced in size over time and with continued implementation. The article sets forth the definition of traditional pedagogy as

"The directed flow of information from teacher as sage to the student as receiver. It can also be defined as a method where the teacher is the sender or source of knowledge the education material is the message and the student is the receiver" (Mbodila, 2012).

This method is deeply engrained in the behavioral learning perspective and has been used for decades. However, one issue with this type of pedagogy is that the student is not defined as a potential source of knowledge or given opportunities to discover answers to their own questions. Instead, they become reliant on the teacher as the sole source of knowledge and neglect to pursue the needed critical thinking skills to succeed in a STEM field. The article argues that if higher education institutions do not repeatedly teach their students new and emerging information communication technology so that they do not fall behind the industry technical standards. The new and differing approaches will encourage students to find their own answers become more active learners that engage in the search for knowledge. In addition, there are five very distinct ways to approach new technology. The four largest categories are: collaborative, creative, integrative, and evaluation. When a classroom is promoting ICT's, the classroom will have "activities determined by learners, students working in teams, finding new solutions to problems, integrated theory and practice, student directed, and diagnostic" (Mbodila, 2012). These learners centered shifts in direction will eventually result in a mindset shift in how the learners approach problems, assignments, and the active pursuit of knowledge instead of being passive learners who depend on their professor as the source of knowledge.

CHAPTER ONE

IMPACTS OF THE PANDEMIC

The impacts of the 2019 Covid-19 pandemic have been widely disruptive to the climate and learning environment for the United States education system. Educators were suddenly swept into an online learning environment without any training for this scenario with no notice or very little notice. In addition, many programs are so heavily rooted in traditional hands-on learning approaches and pedagogy that this sudden change disrupted the physical learning conditions and the mental approach educators must take when educating in a virtual setting. During this time, researchers and educators alike began to ask the question, "what can we do to better prepare for this event ?" There was a feeling as though there were missed opportunities to leverage new technologies to give educators a more extensive portfolio of approaches to teaching. This is where the initial idea for this study originated from and the intention for the usage of the findings. This was not designed to be a replacement tool but rather a supplemental tool that can be used when traditional methods are either unavailable or other constraints limit the usage of conventional methods. This purpose was to determine if students learn and respond to virtual reality activities for reinforcement and retain the knowledge of name and functionality for the parts found in each ink station of a flexographic press. The student group that this study was aimed toward was the major of Graphic Communications at Clemson University. Graphic Communications is a major that prepares students for professional careers in printing, publishing, packaging, digital media, content creation. This major falls within the College of Business and is a Bachelor of Science degree with an emphasis on the hands on and technical aspect of the print and packaging industry and is not to be confused with a Graphic Design program. Flexography is a major area of print and packaging that the students within this major learn and grow in over their four year education.

Group Selection and Pretest

To test this hypothesis, there was a need for a group of students who had no background on the topic of flexography, the parts of the press, and the function of the flexography press. This eliminated students beyond their first semester in a Graphic Communications curriculum as they would already have this knowledge. However, a group of ninety-eight incoming freshmen would collectively take the course GC 1010: Orientation to Graphic Communications, where they would learn presses involved in the print industry and their main parts/functions. This group met the criteria needed to conduct this study and was selected as the sample for the study. Before any of the study could begin, each student needed to be informed of the research and how their personal information would not be shared or compromised in any way during this study. In addition, I explained that the grades on the test would not be factored into their overall grade or GPA. For the study, each part would be graded solely on completion by the assignment date. After identification, the students needed to discover and report on their top results from a Multiple Intelligences quiz. Due to the research by Howard Gardner, STEM students are anticipated to fall within the bodily kinesthetic realm of the multiple intelligences test as the primary way that they learn and retain information is by evoking their primary sense of touch throughout the process. In addition, I had previous interactions with Graphic

Communications students during observation periods which reinforced my belief that they were, in fact, bodily kinesthetic learners before the results of the multiple intelligences quiz came in. While Multiple Intelligences is different from learning, styles educators could use the information in much of the same way. This information can help educators structure projects, and activities tailored to the intelligences found most commonly throughout their classroom. The findings of the multiple intelligences quiz are shown in the table below.

Social	23
Nature	11
Self	13
Musical	20
Language	1
Body Movement (Kinesthetic)	25
Spatial	4
Logic math	1

Table 1.1 : the results of the multiple intelligences quiz. Only top answer recorded for each student.

My theory was supported by the results of the multiple intelligences quiz. Through the research read going into the study, the anticipated outcome for STEM (science, technology, engineering, and mathematics) students was to be highly kinesthetic and social learners. There was a surprising result, with the musical number being as high as it was. However, after taking a closer look, it makes sense that musical learners look for patterns and replication. This is found in the technical mindset of many of the Graphic Communications students and leads me to draw assumptions that this particular group could have more technical minded students than creative focused going in. However, this assumption would not serve as a factor throughout this study but could be used for further research on a different group.

Establishing that the students fall within the group of bodily kinesthetic learners is important for the scope of the study as it brings forward the emphasis that the learners have on being able to have hands-on experiences in lab environment learning. The pandemic effects were felt in much less magnitude for students who are primarily logic-based learners. They do not require the same learning setting and environment as kinesthetic learners do. It is essential to identify what type of learners are in a program before attempting to implement a program to supplement the missing areas. For this group of students, the virtual reality press was implemented as a method to give the feeling of authentic kinesthetic learning and mimic the exploration of these learners in a virtual setting without access to an actual in-line flexographic press. At this point, the study needed to establish a baseline knowledge for the students. It is impossible to identify the impacts of each learning style without a baseline defined to inform what the students did and did not know before the lesson and activity. The purpose of the pretest is to establish a baseline of knowledge on the topic to accurately assess how much growth/retention of information occurred in each group over the exercises. The groups were determined before the pretest was administered. The baseline was established for each group and not as a collective whole and could serve as an equitable way to see growth within each group over the activity.

Groups for Thesis Research

	Group 2	Group 3	Group 1
	33	33	32

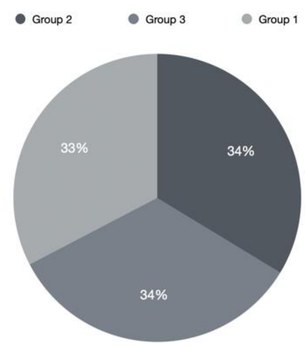

Figure 1.1 : This is how the students were divided into the three separate groups

There were ninety-eight students in total in the study conducted. Therefore, it was not possible to break them apart into three equal groups. They were broken down into 33, 33, and 32. Throughout the study, the smaller group was used as our control group and only received traditional instruction with no auditory or visual simulation. When the students were divided into groups, it was done in a completely random way and did not sort based on gender, race, ethnicity, GPA, or class standing. This randomization increases the variation and randomness in the sample being studied, which is extremely important when the sample size is as small as this one.

The theory behind group one is that they would adhere to the most common pedagogy across college classrooms. An instructor contains the knowledge that they share either audibly or written with the students who are expected to take notes, study the information on their own, and connect the parts to the whole. This teaching pedagogy is known as the Socratic Method. However, as established earlier, Graphic Communications students are primarily kinesthetic learners, and this teaching format is rarely conducive to the retention of learning for kinesthetic-based learners. They require supplemental activities that are hands-on to establish connections and retain knowledge. Group two was set up to adhere to the teaching pedagogy used across campus during the pandemic. This model is based on a traditional lecture paired with a video simulation of the process. While this adds another component, it is still passive learning, which is not ideal for any students, particularly STEM students. Group three was the test group that received the traditional lecture and the VR assignment to enhance learning. The pretest was administered the week before the lecture on flexography was set to be delivered. The results of the pretest are shown below.

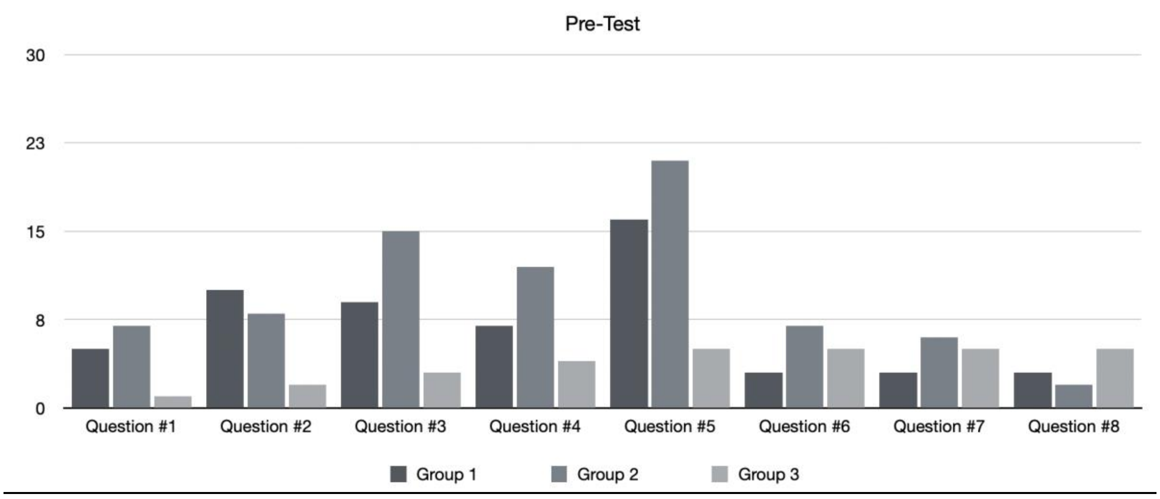

Figure 1.2 : This is the pre-test results for each group. The number shown is the number of correct answers per group for each question.

It is important to see that there were variations between the three groups before the instruction ever occurred. The standard deviation of the pretest for each group can be found in the findings section of this paper. If the assumption that each group was starting from zero, there would have been underlying assumptions that could have skewed the results. Whereas having a baseline defined for each group allows for the growth between the pretest and the post-test to be assessed. However, from looking at the graph and the results for all questions, except number 5, there was minimal knowledge on the topic at hand. This is by no means a mastery level of knowledge that the students have before the instruction occurs. Below is a labeled diagram that was used for the pretest and the post-test.

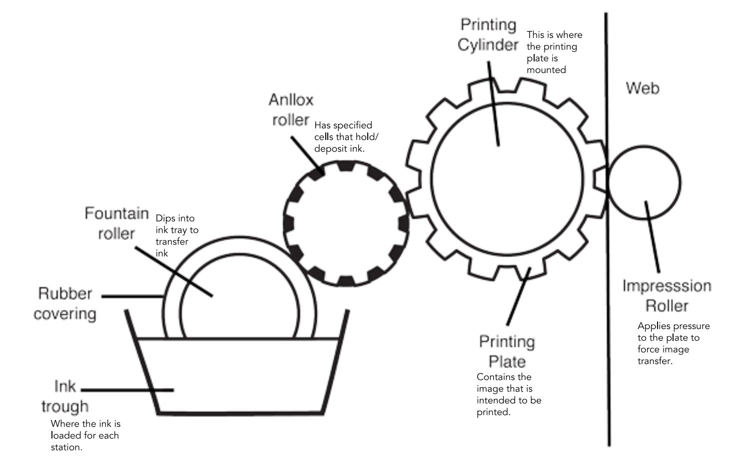

Diagram:1.1 Flexography graph and labeled diagram.

The questions on the pretest and post-test were 1-8 and corresponded with the eight different labeled items that are shown above. This was to look for basic press awareness and comprehension of press parts and pieces. However, the actual questions do not test for application and functionality. It is simply recognition and recall which does not require the same level of mastery as functionality does. This is why an extra credit question was added to the post-test to look for functionality. Understanding functionality is typically more difficult for bodily-kinesthetic students to do and comprehend without being physically present in the lab with the lab equipment. The results of the post-test and the findings from the extra credit questions will be discussed in the findings section of this paper.

CHAPTER TWO

THE IMPACT OF VR

"Virtual Reality is a merging of concepts that come out of several sources, stretching over a broad period of time. Efforts to produce life-like environments go back many years"

(Pantedelis, 1993). This software was first shown to me in 2019 at the Flexographic Technical Association Fall conference in Charlotte, North Carolina. At that time, the software required an HMD (head mount display) and gloves to operate the virtual press. This is too high of a price point and rules out the idea that this could be used for virtual education in higher education conditions. However, after consulting the group that developed the software, the Sonoco Institute at Clemson University, I was informed that since the original launch, they developed a web-based application to use the virtual reality software that was currently in beta testing. The Sonoco Institute was cooperative in my efforts to utilize this in beta testing to conduct this research on the Graphic Communications learning curriculum. The usage of this type of virtual reality pressroom is also ideal for usage in broader education settings because of the ease of use for adoption regardless of budgetary constraints on the school district or university. In addition, during the pandemic, educators in fields that had a traditional hands-on approach were turning toward video instruction and modeling through videos like YouTube to give a broader context and show the students how the process works. While this is a much better alternative for the learning style of STEM students than just staying with the control group pedagogy, it is still passive learning and requires very little active learning and engagement on the part of the student. As explained in the engagement theory, "Students must deem that the material and projects are relevant and motivating in order to see results" (Kearsley, 1998). Providing students with a virtual environment where they must engage in many ways mimics the same traits seen when students do nonacademic exploration through devices like an Xbox while playing a video game. It makes them the lead investigator in their assignment and project. This mindset gets to the core of what is taught to Graphic Communications students and the concept of cultivating students who are problem solvers and investigative. It is almost impossible to create circumstances that force them to be those things while the learning is passive and controlled by someone else.

Methods

The identified students had no prior knowledge of the flexographic print process, and as such, had no knowledge of the print stations for a flexographic press. Therefore, this was an ideal group to select as the sample for this study. All the selected students were required to participate in a pretest evaluation. After the pretest was given, the groups were individually communicated with via email. Their assignments were explained, and the video containing the lecture for the flexography unit was made available. The flexography lecture was recorded ahead of time and was dispersed to all groups to ensure that each group received the same lecture and level of instruction. During the lecture, I discussed the three types of flexographic presses: in-line, stacked, and CI. There was discussion on why flexography is used and what percentage of the print industry it accounts for. In addition, three slides compared the differences in offset lithography and flexography. This background information was given to ensure the students had a well-rounded view of the print process and made the diagram material more applicable. Studies have shown that when students find the coursework relevant, there is a deeper level of engagement. The control group (group 1) just received this lecture in which I went through the parts of the flexography diagram shown above in Diagram 1.1. This is also the diagram that they were shown when they were asked to label the parts of a flexographic press station on the post-test. This lecture was recorded via zoom and distributed to all three groups to ensure they all received the same instructional lecture. They were instructed to watch and take notes over the remaining three days. At this point, I sent out specialized instructions to groups 2 and 3 about what they needed to do for additional assignments. Group 2 was sent a link to a YouTube video in which an industry representative took 10 minutes to walk through the parts of a functional in-line press in the pressroom. In addition, the guide in the video showed the students the actual product that was being printed on the press, which was a shrink-wrap film. This helps to further understand the process by tying the process to a result. However, this is still very passive learning, and the student was responsible for watching the video and listening to what someone else was showing and revealing to them. In a way, this still identifies in much of the Socratic teaching method where the instructor is the sole source of knowledge that passes on to the students. Group 3 received an email from me that gave them a link to the web-based VR virtual pressroom developed by the Sonoco Institute at Clemson University. This software was still in beta testing at the time but was had already been unveiled previously at the 2019 Fall Flexographic Technical Association Conference held in Charlotte, NC. The product launched originally required the usage of HMD (head mount display) and gloves. However, the web-based application is a much more suitable solution for education, as discussed in the literature review portion of this paper and the ease of access to a laptop by all students. In addition, the web-based application reduced the cost of implementing VR, which for education is a significant factor of any new strategy or technique.

In the email sent out to group 3, there was the link, some personal tips and tricks on which web browser functions best, and a blank slate. This was intentional as this was supposed to mimic if they were shown a press in real life. In addition, based on research, STEM students need to engage in active learning that promotes personal exploration.

This would have been hindered if the assignment had been formatted so that their experience in the virtual press room was controlled or preplanned by the instructor. This would provide each student with less of a well-rounded view of the press room and would not promote their sense of self-discovery, and increase their level of autonomy over the interactions that occurred in the press room. In the research before this study, I found out how important students' feelings and attitudes toward a topic could indicate their success. In addition, STEM students needed to feel as though they were 'in the driver's seat' of their experiments, and when this was the design of their assignments, they outperformed their colleagues. Therefore, instead of providing an overly structured virtual reality environment where I read and directed their interactions, I left that up to them.

Findings

My hypothesis was supported, and the results of this experiment reflected that the implementation of virtual reality activities for bodily-kinesthetic learners resulted in better growth and retention of knowledge. In addition, surprising results suggest that virtual reality allows students to comprehend the full functionality of the parts better and not just the recall of the part name when shown on a diagram. While this finding is more difficult to compile quantitive data for, some percentages suggest the group for VR has more success and confidence in attempting questions about functionality. This claim is supported by the percentage attempt at the extra credit, discussed further in this paper.

	A	B	C	D
1	Pretest	Group 1	Group 2	Group 3
2	question 1	5	7	1
3	question 2	10	8	2
4	question 3	9	15	3
5	question 4	7	12	4
6	question 5	*16*	21	5
7	question 6	3	7	5
8	question 7	3	6	5
9	question 8	3	2	5
10				
11				
12	mean	7	9.75	3.75
13	standard dev	4.5669621	5.99404466	1.58113883

Table 1.1 : pretest mean, answers correct, and standard deviation for pretest.

The chart above shows the number of total students in each group who answered correctly on the pretest broken down by question number. For example, in Group 1, 10 students answered question 2 correctly out of a possible 32 as there were 32 students in group 1. The above data reflects that group 3 only averaged 3.75 correct answers per question, coming in as the lowest performing group on the pretest. This suggests that the students had the least knowledge of the subject matter at the beginning of the study. In addition, the standard deviation within each group was calculated. Group 1 and 2 have a high number for their standard deviation suggesting that their data points were dispersed much farther away from the mean and had a greater degree of variance within their groups. Contrastingly, group 3 had a standard deviation of approximately 1.6, which suggests that the data points remained close to the mean, and there was not a great degree of variance. Therefore, the potential for outlier data to exist in group 3 is much lower than in groups 1 and 2. This supports that the students in group 3 had around the same level of knowledge across the entire group instead of being varied as found in groups 1 and 2. The visual representation of this standard deviation can be shown below.

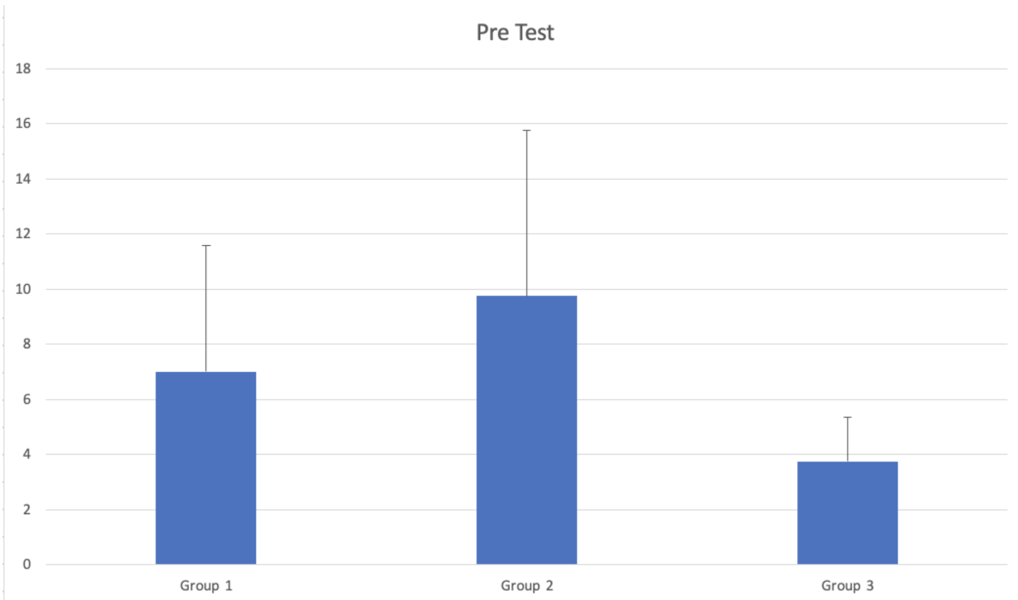

Figure 1.1: Pretest standard deviation.

This data provides a baseline to which the post data can be compared. It reveals the level of knowledge on an overall scale instead of assuming that the entire group of selected students (groups 1, 2, and 3) all have the same level of prior knowledge. As the chart above displays, this would be an untrue assumption, and if the students did not receive this pretest, then the interpretation of the final results would be skewed as it was based on a false premise. As explained previously, the students were given individualized instruction, and the initial data per number is reflected in the chart below.

Post test	Group 1	Group 2	Group 3
question 1	25	27	29
question 2	26	26	28
question 3	30	26	29
question 4	26	26	28
question 5	*25*	24	26
question 6	24	27	26
question 7	28	26	30
question 8	24	27	29
mean	26	26.125	28.125
standard dev	2.0701967	0.9910312	1.457738

Table 1.2 :Post test results, mean, and standard deviation

The chart above shows how many students answered each question correctly out of their respective groups of 33, 33, and 32. The first point of discussion is that the averages between groups 1 and 2 show virtually no difference in performance just on the post-test. In addition, the overall standard deviations within the data for all three groups are much smaller than in the pretest. This is a predicted result as the students had little to no knowledge of the subject matter, so outliers and a wide range of answers are expected. However, the post-test data should have a much smaller standard deviation after the lecture and activities, as reflected in the chart above. In addition, if the averages were rounded to the nearest whole number, a statement could be made that group 3, on average, answered two more questions correctly than either of the other groups in the study. The low number of standard deviations within the groups reinforces my belief that this data is correct and reliable. This is shown below in a graph.

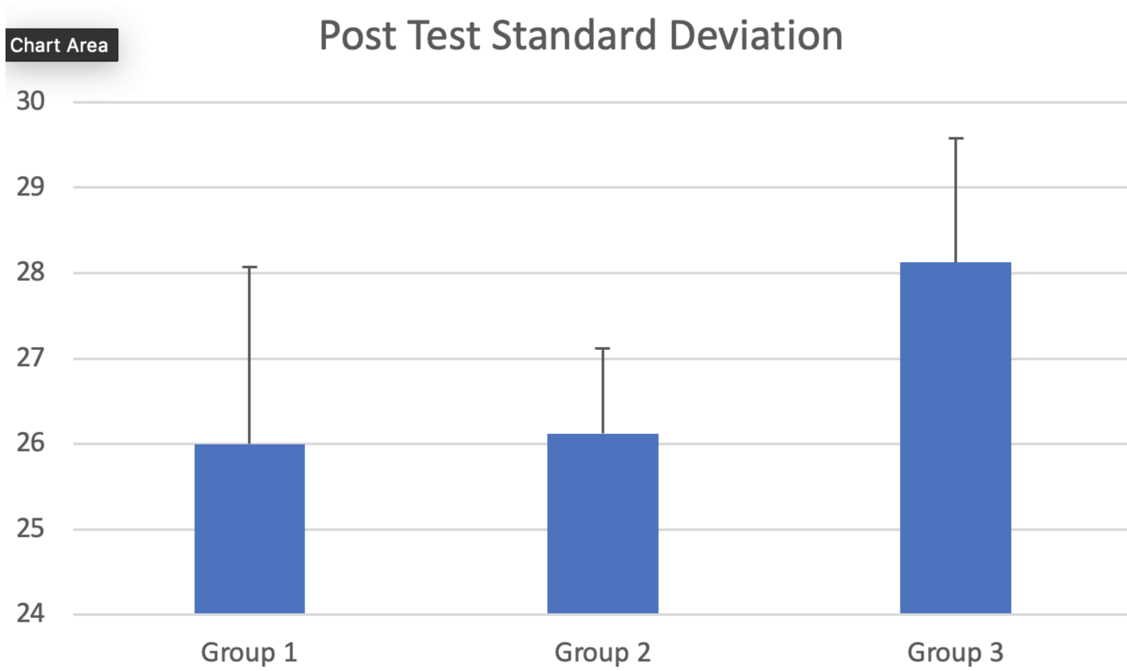

Figure 1.2: Post Test Standard Deviation

As you can see, group 1 has the most significant standard deviation, as represented in the numbers above and reflected in the graph. In addition, group 2 has less than 1 question for a standard deviation leading me to believe that the retention of information was consistent within group 2 even though their overall scores came in lower than group 3. Looking at the group, the students consistently outperformed the other two groups on the post-test. However, it is important when looking at this data to compare back to the original baseline to demonstrate how much learning occurred during the study. As shown earlier, the averages for the pretest for the number of correct answers per question were 7 for group 1, 9.75 for group 2, and 3.75 for group 3. This puts group 3 as the underperforming group before the learning and assignments occurred. When calculated for the post-test results, these same averages were 26 for group 1, 26.125 for group 2, and 28.125 for group 3. To find the growth that occurred during the study, these averages from the post-test must be evaluated against the numbers from the pretest. This means that the average point growth during the experiment was 19 for group 1, 16.375 for group 2, and 24.375 for group 3. This shows that group 3 outperformed groups 1 and 2 for recall and retention on a significant scale. They averaged 5.375 greater than either of the other two groups being evaluated during the study. Supporting the hypothesis and providing factual data that the implementation of virtual reality offers increased retention and recall rates for STEM/Graphic Communications students.

In addition, there were more surprising findings throughout this study that were subsequent from the original scope of the study but are important and could be helpful in future research and studies in this area. There was an extra credit question on the post-test that was intended to check for functionality, not just simple part recall, as seen in the labeling of the diagram in the pretest and post-test. This section of the assessment is shown below.

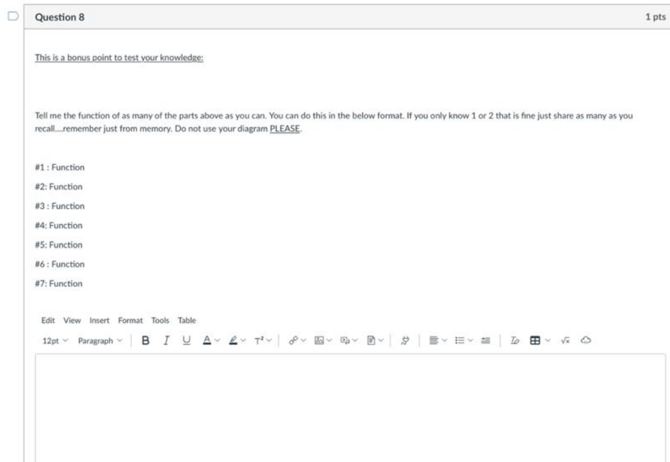

Figure 1.3: Posttest extra credit attempt

As you can see from the diagram above, this was an optional part of the assessment, and they were encouraged to attempt it even if they could answer 1 or 2 of the questions. The task at hand was for them to tell me the functions of 7 different parts of the flexographic press labeled in the diagram that has been shown previously. Group 3 outperformed groups 1 and 2 in both numbers of attempts at the extra credit and overall correct labeling of the function of the parts of the press. During the recorded lecture distributed to all three groups, I briefly talked about the functionality of each press part while labeling the diagram to give students more space to form connections regarding press parts and press function for a well-rounded view. Therefore, each group hypothetically had the same chance at answering these functionality-based questions across the three groups. However, Group 3 had 21 students attempt the extra credit, group 2 had 15 students try the extra credit, and group 1 only had 9 students attempt the extra credit. This means that 64% of group three attempted the extra credit, whereas group 2 had a 45% attempt rate and group 1 had a 28% attempt rate. While I recognize that this part of the assessment was not mandatory and therefore may not have been deemed necessary for all students, that feeling and variations should have been distributed more evenly than seen in these results. In addition, group 3 had more correct answers for the functionality than any of the other two groups who did attempt. This data suggests that bodily-kinesthetic learners can better understand the press on a large scale when they are given assignments that promote active learning and can utilize new technologies in the classroom. As seen above, the traditional group, group 1, performed comparably for the recall section of the assessment but struggled significantly on the functionality section. It could be that they felt less confident because they did not have project reinforcement or simply that these students typically respond better when given material that is tailored to their level of multiple intelligence and helps them grasp very hands-on concepts while in a distance learning scenario.

Threats to the Study

While the study variables were controlled as much as possible, it is untrue to know that there were no internal and external influences that played a role in the results of this study. To determine if these pose a threat to the study's validity, it should be repeated numerous times with much larger and more diverse sample sizes. One factor that needs to be considered is that there were seven students who would have had prior knowledge due to being enrolled in GC 1040, where this content was covered extensively as it is one of the primary print methods taught in the course. Therefore, this could have thrown off the pretest and post-test numbers slightly. These students were spread between the three groups evenly; group one had 3, group two had 2, and group three had 2. The goal was that by spreading these students evenly throughout the groups, they would offset and would not cause a threat to the overall validity of the study.

Another factor that could have impacted the study is that for group 3, the assignment within the virtual reality press room was not controlled, and each student had a different interaction. This means that some students could have taken the time to see all eight ink stations, the final product, and the surroundings. While others just looked at one ink station and logged off. However, if the environment were structured, it would have been leaning toward passive learning. Each student would have been looking only at what was given to them in the instructions and not taking full ownership of the assignment, which was the point of the study. However, there could be an argument that the students had such different experiences that it is a threat to validity. This could be eliminated as a threat with repeated trial runs.

In addition, there is no concrete evidence that can eliminate that these students did not use their diagrams on the assessments to give artificial data. This was highly discouraged at every possible turn of the study, and students were told that their score on each of the assignments would not be graded on anything other than participation and completion. Therefore, there was no incentive to use the diagram to provide inflated scores. Still, these assessments were both given through canvas online, and there was no proctor present to eliminate this threat to the study. Another factor to consider is if each student in groups 2 and 3 followed through with their assigned assignment. I sent out assignment details to each group. Based on email responses from these groups, I believe that there was significant participation as there were issues accessing the YouTube video and problems getting the virtual reality software to load at times. However, if some students did not follow through on their assignments, this could pose a threat to the validity of the study overall. I would argue that this would be much like any other type of activity assigned by an instructor, whereas the instructor only has the results on the final assessment to determine if the students did the assigned work or not. Typically, at the collegiate level of education, this is normal to give self-guided activities, and students are expected to participate and follow instructions.

CHAPTER THREE

FUTURE RESEARCH

This research left me with as many or more questions than it provided answers. To which, I would like to credit the research a success, as asking questions should lead us further into exploration ourselves. This study should be conducted on a larger sample size and different academic disciplines within STEM. While the focus of this study was Graphic Communications, this type of learning is present in engineering, nursing, chemistry, and much more. Virtual learning environments could be expanded and adapted to almost any imaginable situation, and the limitations on the software are becoming minimal. Investing in more research into Virtual Reality learning environments for STEM students could allow educators to be better prepared for virtual learning situations and help higher education officials look at expanding programs using these methods to reach nontraditional students. In addition, it should be studied in the context of industry training. One issue as frequently discussed by the Flexographic Technical Association (FTA) is the lack of proper training and qualified applicants in the industry. Virtual reality could pose an effective and low-cost way to train large cohorts of employees on a consistent platform that engages them while keeping safety as a top priority by not training on a live press. This is not to say that additional training would not be required. However, it is safe to do this in a virtual environment and would provide each employee the ability to learn and do things at their own speed, whereas in person training often moves at the instructor's speed without much feedback. In addition, if companies decided they wanted to do introduction or low-level press training through virtual reality, there is an avenue to partner with technical schools and trade programs to fill their employment needs with qualified workers who have been trained on their exact systems via virtual reality without ever taking many of their in-person resources. A study conducted in 2010 associated with automobile manufacturing went into this area of research and had interesting findings.

Another way that this research could be studied is by looking at the training or learning differences within the workforce. It could be possible that how millennials and younger generations can learn and use technology versus their older peers in the workforce who did not grow up with immediate access to technology. This could be an opportunity to take a study that started by asking the question of 'how do we teach STEM students' and build on it by asking 'how we should train our employees'. I suspect that there are vastly different training needs based on age demographics within the workforce.

In addition, this research could and should be expanded to cover more than just a flexographic press. To truly make assumptions about an entire group of students or majors, this needs to be repeated for at minimum offset lithography and screen printing. Now that it is seen that the Sonoco center has the resources and capabilities to develop virtual reality press rooms, there should be press rooms for other areas of print production developed and tested in this same method. This would both serve as a device that could help Graphic Communication educators if a situation ever arises again where there is a need for virtual or distance learning. It would also give data to confirm this study and further suggest that Graphic Communications students are STEM students who fall in the category of bodily kinesthetic learners and retain/recall knowledge at a higher percentage when they are given lessons and educated utilizing virtual reality active education techniques.

Another way this research could be built upon is by conducting a mixed methods research study. This could look like repeating this study on a larger sample size or throughout different STEM disciplines in higher education. This research could be paired with qualitative research in the form of a survey for the students that collects data on their attitudes toward virtual reality. Is this a software they enjoy using? Do students find virtual reality assignments difficult or confusing? Do students perceive learning through new technologies as relevant to their education? When virtual reality assignments in education were being studied twenty years ago there seemed to be a disconnect between students on their attitudes toward virtual reality. Was this due to a new generation that is familiar with technology? Does this new shift in technology signify there should also be a shift in education approaches?

Another area of continued research I would be interested in is the cost evaluation side of virtual reality. How cost effective is it for a higher education institution like Clemson? Could this be a viable resource that we provide for students to get even more time 'on press'? Could this be a way for students to do a press run on a virtual reality press simulator with their files and troubleshoot issues digitally before using resources and equipment in the lab area? In addition, could virtual reality be turned into an area of quality control as it would provide a way to run the press and produce a result that could serve as a proof and allow students to identify mistakes? There is still so much left to be discovered about how virtual reality can be implemented into higher education and what the limitations are on this software.

CHAPTER FOUR

CONCLUSION

This study revealed that using virtual reality could provide a way to broaden the methods current educators in higher education have to teach students with different multiple intelligences. The idea behind this study is that it could add ‘more to the toolbox’ for educators in an effort to better prepare higher education educators for potential shifts to distance learning when appropriate due to pandemic situations, lack of classroom space, infrastructure lack of funding, or the desire to give students a variety of learning opportunities. While the necessity of this study arose due to the pandemic and immediate shift the results found from the study could be applied to traditional learning to enhance the number of times students have access to a press throughout each activity. Through the study the results support that graphic communication majors are bodily kinesthetic learners who respond and retain both recall and functionality when given assignments in a virtual environment versus more traditional approaches. This study has shown that when compared to traditional lecture learning or video simulation they preform much better when given active learning assignments over passive learning assignments. In addition, when educators adopt and implement new technologies it provides support to continue the research and expansion of these teaching techniques to further support educators in their multiple avenues and methods of teaching. This study should serve as a jumping off point for future virtual reality studies within the STEM discipline as I feel it would be transferable due to their shared learning style and dependency on traditional in person laboratory teaching.

Resources

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APPENDICES

Appendix A: Coursework Correspondence

Labeled Flexography Diagram

Quiz Instructions

I have explained that our assignments surrounding Flexography are being used for research . As such, I want to make sure that I have consent from all of you to use these findings in my research. I will NOT be using your names and grades. I will be using overall trends of grades and improvements.

You just need to fill in the blank with either , I consent or I do not consent.

This is graded on your participation NOT your response

Question 1 **1 pts**

Ms. Gibson has explained to me that our flexography unit is part of research. I willingly consent to my participation in this study and understand my identity and personal grade will be kept confidential.

Figure A-1: This is how I gathered consents from students to participate.

Group 1 Email

GC 1010 - Group 1

HG **Hanna Gibson Gardner** Wednesday, December 9, 2020 at 8:56 AM

To: paltman@clemson.edu; etblack@clemson.edu; hbook@clemson.edu; kboyd5@clemson.edu; +30 more

Good morning and Happy Wednesday!!

For your assignment you will simply watch the lecture video on canvas and study the diagram attached. I will post a quiz tomorrow that is due by Friday at 5PM and once you complete that quiz you are done.

Please remember the quiz is graded on participation and effort. I really just need you guys to be honest and not use the diagram on the quiz....if you truly do not know that is not going to impact your grade.

--

Hanna Gibson
Student Services Coordinator
Registration Coordinator
200D Godfrey Hall
864-656-3447

Department of GRAPHIC COMMUNICATIONS

Figure A-1: This is the email sent to students once they were divided into their groups. The figure above was for group 1.

Group 2 Email

GC 1010- Group 2

HG **Hanna Gibson Gardner** Wednesday, December 9, 2020 at 9:00 AM

To: mmilani@clemson.edu; daisym@clemson.edu; tbmitch@clemson.edu; +31 more

flexo_diagram-lg.pdf
47.7 KB

Download All   Preview All

Good morning and Happy Wednesday!

For your assignment you need to watch the lecture posted on canvas, review the diagram attached, and watch the video linked in this email. This video is very short!

Once you complete those tasks, there will be a quiz on canvas posted tomorrow that is due Friday at 5PM. Then you are done! Please remember with the quiz to simply do your best and not use your diagram etc. I want to see what you know and if you miss a few or are not sure still that is OKAY and will not impact your grade. Just do your best.

https://youtu.be/hTF_fgpWoTo

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Figure A-2: This is the email sent to students once they were divided into their groups. The figure above was for Group 2.

<u>Group 3 Email</u>

Mark this item as read or unread roup 3

Hanna Gibson Gardner — Wednesday, December 9, 2020 at 9:09 AM

To: jek2@clemson.edu; olane@clemson.edu; walangs@clemson.edu; jmahaff@clemson.edu; +33 more

flexo_diagram-lg.pdf 47.7 KB

Download All Preview All

Good morning and happy Wednesday!

For your final assignment you need to watch the lecture posted on canvas, review the diagram attached, and explore the VR flexo software.

For the VR software. RUN THIS USING GOOGLE CHROME. I tried in safari and no luck at all!! There is no strict assignments for this simulation. My advice / recommendation is that you set a timer for 15 minutes and truly just get curious and test it out. If you end up spending more time in the software that is fine (truthfully it is super neat and some of the newest software) !

http://nathann.people.clemson.edu/StripeTest/

Once you do all of this there will be a quiz posted on canvas tomorrow that is due by Friday at 5PM. Please do not use your diagram or other materials on the quiz. I just truly want to see what you know , if you miss a few that is OKAY and will not impact your grade. Just do your best! This is to see how much you know.

--
Hanna Gibson

Figure A-4: This is the email sent to students once they were divided into their groups. The figure above was for Group 3.

<u>Appendix B: Learning Materials</u>

<u>Flexography VR Interface Landing Page</u>

Figure B-1: This is the landing page students click the link provided in the email. They used standard print run.

Flexography VR Press Room View

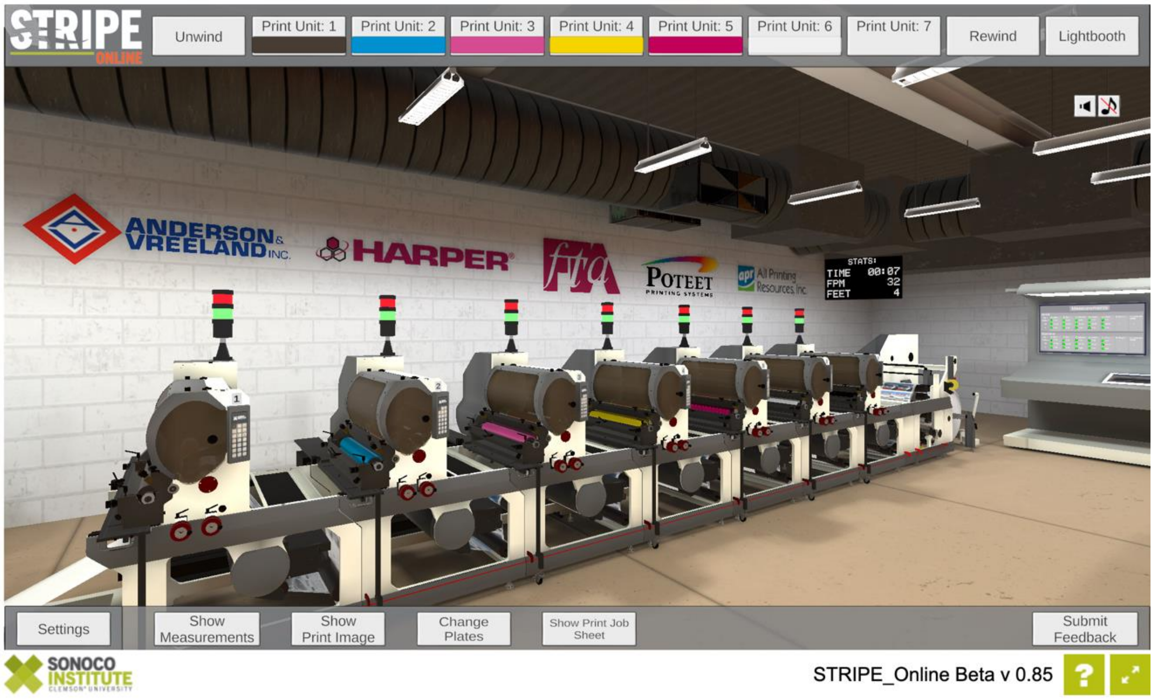
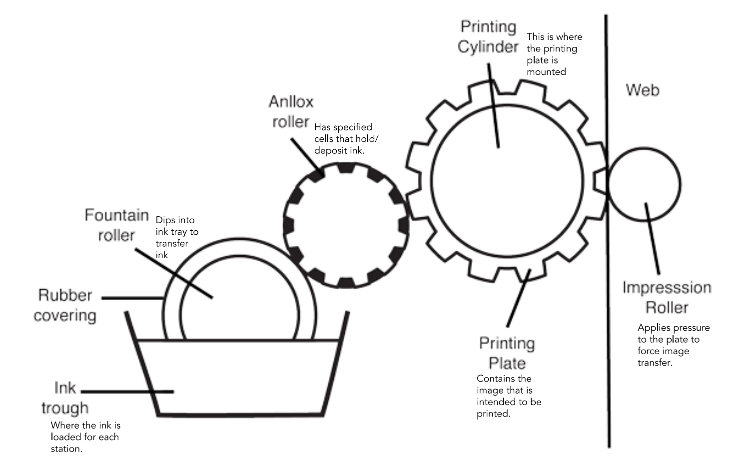
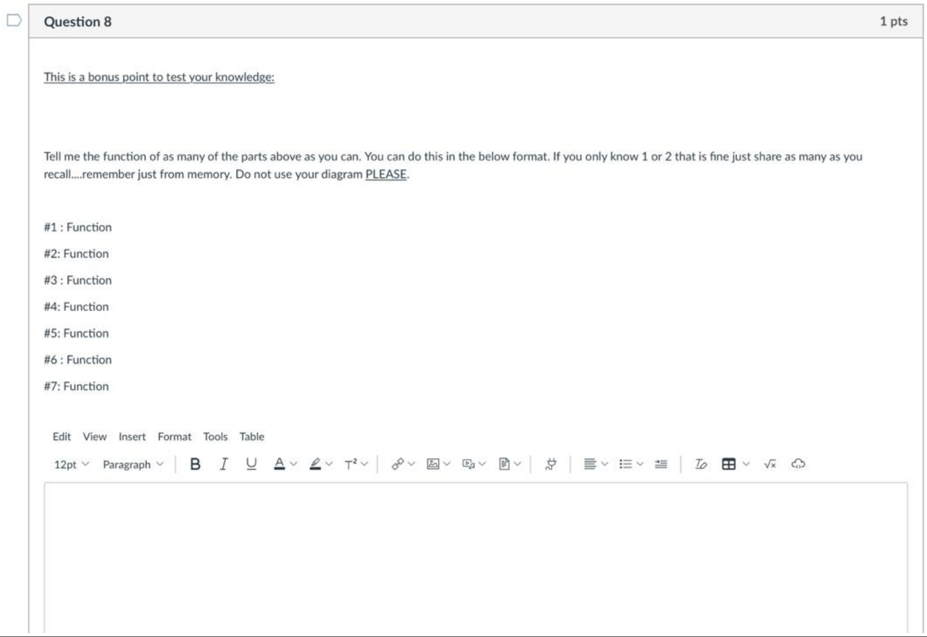


Figure B-2: This is the Virtual Reality Press Room that has the print units shown and listed at the top, a light booth, a measurement tab, and a label part tab that they were encouraged to turn on.

Labeled Diagram





Question 8 1 pts

This is a bonus point to test your knowledge:

Tell me the function of as many of the parts above as you can. You can do this in the below format. If you only know 1 or 2 that is fine just share as many as you recall....remember just from memory. Do not use your diagram PLEASE.

#1 : Function

#2: Function

#3 : Function

#4: Function

#5: Function

#6 : Function

#7: Function

Edit View Insert Format Tools Table

12pt Paragraph

Appendix C: Charts and Figures

Pre- Test Results

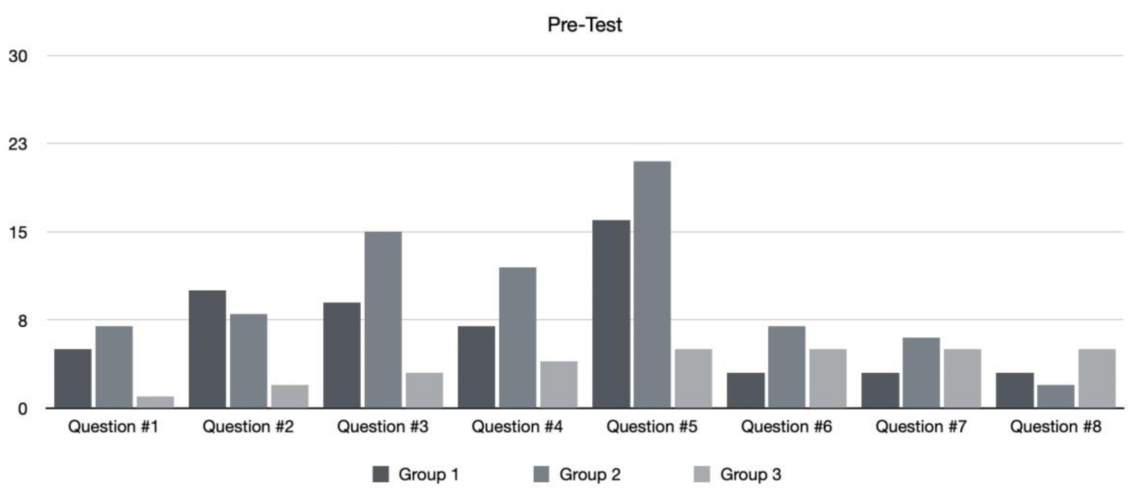


Chart C-1: This is the pre-test results for each group. The number shown is the number of correct answers per group for each question.

Extra Credit Attempt: Functionality

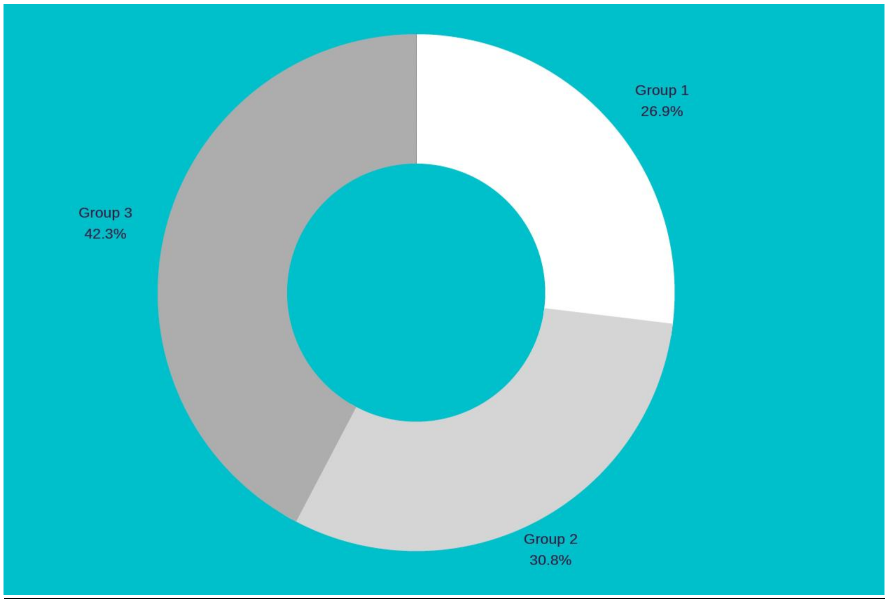


Chart C-2: This is the percentages of each group that attempted the extra credit.

Class Multiple Intelligences Result

Social	23
Nature	11
Self	13
Musical	20
Language	1
Body Movement (Kinesthetic)	25
Spatial	4
Logic math	1

Table C-2: This is the total class results for the multiple intelligences quiz. Only the top 1 was recorded per each student.

Groups for Thesis Research

	Group 2	Group 3	Group 1
	33	33	32

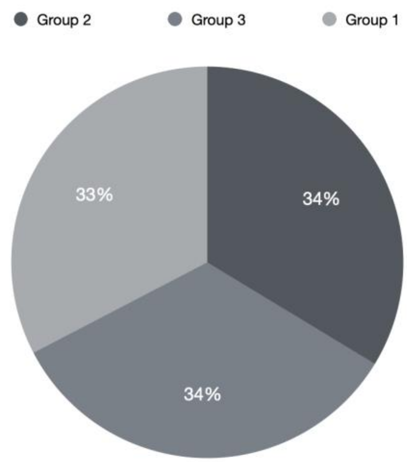


Table C-3 : This is how the students were divided into the three separate groups.