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Virtual Reality and Art History: A Case Study of Digital Humanities and Immersive Learning Environments

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The potential benefits of integrating immersive realities into traditional humanities curricula have been touted over the last two decades, but budgetary and technical constraints of implementation have limited its adoption. However, recent advances in technology, along with more affordable hardware coupled with more user-friendly interfaces, have seen widespread adoption beyond that of the military and healthcare. In fact, higher education institutions are poised to adopt VR on a broader scale to enhance learning with virtual environments. This study seeks to determine the expectations and results of integrating virtual reality into coursework with students and faculty in Art History. The study surveyed students, first to ascertain the prevalence and familiarity of immersive reality technologies, as well as the perceived benefit of integration into curriculum. Next, surveys collected data on student experience relating to virtual reality assignments integrated into coursework for both face-to-face and online learners. The results provide a model for other institutions for a variety of disciplines to reinforce outcomes through strategic use of the technology.

Keywords: virtual reality, digital humanities, art history, immersive reality

INTRODUCTION

Immersive realities (IR) have been radically transforming the delivery of educational materials since the 1990s (Biocca & Levy). In an age of social and cultural evolution, technology is no longer a novel addition to an academic tradition now over two centuries old of the sage on the stage. Yet, the introduction of new technologies to support course delivery and learning outcomes, and the resistance against them, is not new. The introduction of the chalkboard into classes after 1801 was met with widespread revolt from students who had been trained to memorize instead of writing out (Krause, 2001); the adoption of the magic lantern in universities in the nineteenth century, replacing engraved works of art, was slow due to its perceived use primarily as a device for entertainment (Shepard, 1987). These technologies reshaped higher education as we know it today, but 2020 saw another watershed moment that is forcing another evolution to move us beyond the modalities we are familiar with today. At the same time, students have unprecedented access to information on demand. A shift is occurring for faculty in postsecondary education from imparting information to facilitating learning in active learning environments (Brownridge, 2020). The shift occurs at a time when students now represent the first generation of digital natives, never having known a time without computers, video games and smartphones. Technology pervades their lives- how they gain access to information, socialize, and get access to goods and services. Not surprisingly, there is a disjuncture between experiences students have prior to entering college and technologies used in most classes (Flynn and Frost, 2021). Both Generation Z and Generation Alpha, who will soon enter college, have higher expectations for the integration of technology in postsecondary education. At the same time, most faculty are digital immigrants, who learned to adapt to new technologies in adulthood (Prensky, 2001). The resulting lack of adopting new technologies is often blamed on teachers (Ertmer and Ottenbreit-Leftwich, 2010; Howard & Mozejko, 2015). However, little support has been provided by way of examples, resources, and the like to assist faculty in adopting new technologies such as Virtual Reality (VR) (Howard & Mozejko 2015; Licastro, David Nieves, & Szabo, 2020). This study seeks to assist by providing practical examples for faculty teaching using digital humanities in visual culture areas.

The pace of immersive reality adoption in higher education institutions in the United States is fast accelerating with a projected 60% using VR by 2021 (Resnick & Morgan, 2017). A new paradigm will emerge to replace either face-to-face engagement with students in classrooms: recorded video lectures for online, asynchronous learning and distance education, or blended or hybrid learning environments, such as the HyFlex model adopted to address the challenges wrought by the 2019 COVID-19 pandemic. Immersive realities, including Augmented Reality (AR), Virtual Reality (VR), Augmented Virtuality (AV), and Mixed Reality (MxR), which have been used primarily in science programs across the nation, will become as common a language for academics over the next decade as Learning Management Systems (LMS) and Microsoft Office. The advances made in Head-Mounted-Displays (HMDs) that allows for both audio and visual immersivity and expanding libraries of educational applications, coupled with a lower price point, have removed many barriers that had previously prevented widespread adoption in academia (Bekele & Champion, 2019).

The alignment of possibilities has never been timelier and more welcome as higher education continues to grapple with the realities of teaching during a pandemic, a public that questions the value of a postsecondary education due to rising tuition costs, and a recession that has exacerbated the effects of inequality in the country. The ability to bring the world to students through IR is merely for entertainment, it addresses all of these concerns and is able to "level the playing field" for those who would never have been able to have direct, physical experience with locations and material culture necessary to excel in this and other fields. While travel restrictions became the norm in 2020, study abroad trips were all put on hold as countries shut down for wave after wave of outbreaks. Travel and study abroad are often taken for granted as part of the college experience and necessary for emotional growth and independence, yet only a small percentage of students in the United States are able to afford the additional costs on top of their tuition and room and board (Bandyopadhyay & Bandyopadhyay, 2015). Additionally, there has been a significant demographic shift in higher education with the traditional 18- to 24-year-old population, who live on campus and do not work, has steadily declined over the past thirty years. Today, most students attending college would be classified as non-traditional, older and work full-time (Weise, 2020).

In order to meet the current and future needs of an increasingly diverse student population, and in response to the recent advancements in VR technology, the Art History and Visual Culture Department in the School of Arts, Media, and Communications at Lindenwood University piloted an integration program that sought to develop a model that the rest of the university and other institutions could adopt. This model is based on the best practices of educational IR that is scalable and user-friendly for both faculty and students. Resnick and Morgan (2017) recommend beginning with the "buy rather than build" strategy for institutions, ensuring applications address learning outcomes first before developing original content. The initiative was funded through a university grant- the President's Research, Innovation, and Development Towards Excellence (PRIDE). The Immersive Realities Integration and Adoption Project (IRIAP), funded from January- December 2021 provided the resources to acquire the first twelve Oculus Quest 2 headsets to familiarize faculty with their functionality and to identify appropriate applications for their subject areas.

This study seeks to investigate the perceived educational benefits and technical and pedagogical challenges of using VR technology from both student and faculty perspectives, as well as identifying the best strategies for how and when to incorporate the technology into postsecondary curriculum. The study surveyed the experiences of students in both online and hybrid courses in the department of Art History and

Visual Culture in the academic year of 2020-2021. Data was also collected from two faculty from each school across the University to ascertain the digital pedagogical challenges in various fields of study. The student survey tool used sought to gather demographic information, including first-generation status, age, gender, race and ethnicity, and major, as well as familiarity with technology in general, potential complications with use, the type of experience, and perceived usefulness of VR technology compared to other media. The faculty survey tool likewise collected demographic information, including race and ethnicity, gender, age, and familiarity with technology in general, potential complications with use, and likelihood of adopting for their fields. Results were measured via a Likert scale for both faculty and students. Students were asked to identify if the course utilizing VR technology was a major requirement or general education course and whether it was required or extra credit. Students were then asked to rank the usefulness of the technology for achieving learning goals and if they would prefer to see the headsets used in other coursework. The survey concluded with an open-ended question to assist in identifying any additional considerations students and faculty had with regards to VR adoption.

The results of the study confirm the findings of previous studies, especially the positive correlation between the use of the immersive technology and increased enjoyment of learning (Apostolellis & Bowman, 2014; Ferracani, Pezzatini & Del Bimbo, 2014), motivation (Cheung et al. 2013; Jacobson et al. 2005; Sharma, Agada & Ruffin 2013; Brownridge, 2020), deeper learning and long-term retention (Huang, Rauch & Liaw, 2010; Rizzo, Bowerly, Buckwalter, Klimchuk, Mitura, & Parsons, 2006; Hussein & Nätterdal, 2015). The study confirms that most students in the department identify as Caucasian female between the ages of 21 and 24, but regardless of demographic background, students claimed to have familiarity with VR technology, and most were "moderately knowledgeable" with technology in general. Half who participated attended an orientation on immersive realities at the outset of the term that likely led to greater familiarity and ease of use for a better first experience. Of the available applications for students to select, most chose a 360-degree video, with an immersive simulation or training coming second, followed by a VR documentary as the most popular. Overwhelmingly, students agreed that the VR experience helped them learn and understand the material better than a reading or traditional video alone. There were some technological issues and/or VR sickness reported by a small percentage of respondents. At the same time, only half of the polled group stated that they would like to see such experiences integrated into other coursework. The students attending face-to-face in a hybrid format were required to go to the Gaming and Media Lab to use the Oculus Rift for a specific assignment, while online students were given greater flexibility as the headsets were not yet required for students to participate in these classes, though they will be starting Fall 2021. Faculty, all of whom were full-time, on the other hand, reported that the technology was easy to use for a beginner with a minimal start-up learning curve. Additionally, faculty agreed that the headsets would be "very to extremely useful" for their various fields. While the potential for various fields was agreed upon, most faculty had difficulty in finding useful applications readymade and tailored to their areas, especially in the Health Sciences and Business. These areas noted that custom-built platforms to simulate labs or other relevant experiences would need to be explored prior to widespread adoption. The recommendations of the study, which may be applied to all disciplines for consideration, include a "buy rather than build" initial strategy—using existing applications and then building institutional capacity to develop unique experiences tailored to specific learning outcomes and disciplines.

LITERATURE REVIEW

Virtual Reality in Education

Virtual reality has many definitions, but for our purposes we will rely on the understanding provided by Pope that it is "an experience that encompasses most of the senses, including sight, hearing, and touch, and represents an alternative to reality" (Pope, 2018). Previous literature has focused on the use of virtual reality for education in a general fashion, such as McLellan (1996 updated in 2003), who provided a comprehensive review. Early use of the technology was traced to training in flight simulators with head-mounted displays that were developed in the 1960s and 1970s (McLellan, 1996). Schroeder (1993) and Boyle (2017) also trace the history of early education and training of VR within the military for battle simulations. In addition to McLellan, Youngblut (1997) also undertook a survey of the educational uses of virtual reality in the 1990s. The survey focused on K-12 education and sought to identify the use and effectiveness of virtual reality using a constructivist framework for learning. Kavanaugh, Luxton-Reilly, Wuensche, Bukhard, and Beryl (2017) noted that most researchers approach the use of virtual reality as a way to improve the intrinsic motivation of students. In doing so, only a small number of factors have been considered, including the use of a constructivist pedagogy, activities that involve collaboration among students, and the gamification of the experiences.

The limitations of available scholarship and range of studies can be attributed to the budgetary and technological constraints faced by previous educators. While Sutherland and Sproull are credited with the first virtual reality headset in 1968, the technology has not been widely available, and headsets themselves have only recently become a viable option for most faculty. Beginning in 1993, a number of video game studios began designing software for virtual reality head-mounted displays (HMD), starting with SEGA, followed by Nintendo in 1995, both of which were a commercial failure (Horowitz, 2004; Kushner, 2014). The first headset that was released to the consumer market that could be considered successful was the Oculus Rift in 2013. While the unit was primarily designed for the gaming market, it also supports educational applications (Moorefield-Lang, 2015). Since 2013, a number of other virtual reality headsets have been released, representing a range of quality and immersion. For example, the Google Cardboard uses lenses and a smartphone to give users a virtual experience, which is of lower quality and immersion, but does not require expensive hardware or a dedicated physical space. In 2016, the HTC Vive was released and became popular due to its sophisticated optics and its use of the already-popular game distribution service Steam. However, it requires connection to a high-powered computer to run and avoid lags. Oculus, which was purchased in 2014 by Facebook, began by releasing self-contained headsets, such as the Oculus Go and Quest, which provide a less sophisticated immersion experience, but are cheaper and do not require an external computer. The usefulness of the technology was further expanded when Facebook released the Oculus Quest 2 in October of 2020. The latest generation has overcome the earlier limitations outlined by Kavanaugh et al. (2017), including price point, consumer availability, and user experience. With consumer technology now available and affordable, VR headsets are likely to become as standard a piece of educational technology as the Personal Computer or word processor.

Virtual reality has proven to promote many positive outcomes with regards to different aspects of learning. Salzman, Dede, Loftin, and Chen (1999), for instance, outlined a model that assists in describing how virtual reality improves conceptual learning, along with how those factors influence the learning process and outcomes. Such claims are supported in studies that demonstrate how a virtual environment is able to “stimulate learning and comprehension, because it provides a tight coupling between symbolic and experiential information” (Bowman, Hodges, Allison, and Wineman, 1998, p.121). There is a consistent positive correlation between use of immersive technology and motivation (Cheung et al. 2013; Jacobson et al. 2005; Sharma, Agada & Ruffin 2013; Brownridge 2020), time-on-task (Huang et al. 2010; Johnson et al. 1998), increased enjoyment of learning (Apostolellis & Bowman, 2014; Ferracane, Pezzatini & Del Bimbo, 2014), deeper learning, and long-term retention (Huang et al. 2010; Rizzo et al., 2006; Hussein & Nätterdal, 2015). Beyond these pedagogical considerations, Dalgarno, Hedberg, and Harper (2002) also noted that the most significant educational contribution of virtual reality is the ability to facilitate spatial knowledge development using 3D learning environments (3DLEs). The research was continued by Selvarian (2004), who investigated the notion of presence using spatial and social technologies in virtual learning environments (VLE). She hypothesized that a VLE model correlated spatial and social technologies with spatial and social presence. Finally, Lee and Wong (2008) note how VR was identified early on as a possible educational tool specifically tailored to improve performance and conceptual understanding of several fields.

However, there is a limited understanding of exactly how VR can be used to enhance specific learning outcomes. Studies have long been conducted on the nature of interaction and engagement as it pertains to memory retention (Wickens,1992). Kavanagh et al (2017) also point out that despite the fact that much of the research on the topic is meant to inform educational design, there is little consideration of pedagogical reasoning. Chen (2006, p.1) likewise asserted that “although VR is recognized as an impressive learning tool, there are still many issues that need further investigation including, identifying the appropriate theories and/or models to guide its design and development, investigating how its attributes are able to support learning, finding out whether its use can improve the intended performance and understanding, and investigating ways to reach more effective learning when using this technology, and investigating its impact on learners with different aptitudes." Lee and Wong (2008) rightly noted that no technology should be indiscriminately used in any educational program. Learning outcomes are paramount for successful integration and must be carefully considered. Sanchez et al. (2000, p.234) outlined the questions that need to be answered for successful outcomes associated with IR, including: "What are the appropriate theories and/or models to guide the design and development of a VR learning environment? What disciplines or subjects and what sorts of students require this technology? How are VR systems capable of improving the quality of student learning? When and why VR is irreplaceable?" These early questions guided the efforts of those that followed in developing theoretical models for understanding specifically and in what way VR influences learning processes and outcomes in virtual learning environments.

The first model for understanding how VR benefits students in complex conceptual learning through virtual learning environments was Project ScienceSpace in 1999. Developed by Salzman, Dede, Loftin and Chen, the project consisted of virtual learning environments for science instruction: Pauling World, Maxwell World, and Newton World. The results of this immersive model served as a model for further studies on the efficacy of educational applications. The model moves beyond the interaction between hardware (headset), software (application), and user, to a more nuanced understanding of how the features of VR work in tandem with other variables, such as idea or task to be completed or learned, individual learner characteristics, and, finally, the interactive learning experience that influences the actual learning process and outcomes (Salzman et al., 1999). According to the researchers, before designing and developing educational applications in VR, the outcomes must be clearly identified and align with the appropriate features to support them. The three key features VR technology makes possible with such a model include: multisensory cues, multiple frames of reference, and immersive 3-D representations. The effectiveness of the learning experience is predicated on the learner's individual attributes, which include spatial ability, penchant for motion sickness (otherwise known as VR sickness), gender, and other immersive tendencies. The categories have been continued in research on the use of user experience (UX) design as it pertains to VR by Kavanaugh et al (2017) finding the following most useful in considering the success of an experience: Immersion, Presence, Disorientation, Sense of Control, Pleasantness, Exploration and Simulator Sickness. As each learner is unique, so is the experience in the learning environment. Pertinent to the study at hand, while an IR experience is immersive and engaging, this model confirms that educators must begin with the end in mind and consider how the selected application/experience enhances, reinforces, or supports the learning objectives for a particular course learning objective. Next, considerations of individual learner characteristics need be reviewed, and alternative experiences provided for those susceptible to VR sickness.

Despite these early positive results of studies of using VR in education, broad recommendations for its application are still in development. One reason, as noted, is that most studies are limited to training and the medical fields, thus not enough research has been conducted on other applications in other educational areas. Radianti, Majchrzak, Fromm, and Wohlgenannt (2020) also noted that in existing literature the most popular topics for VR in education are still medicine (78%), social science (15%), neuroscience (11%), and psychology (11%). The technology was (and continues to be) predominantly used in applied fields such as aviation and medical imaging. Likewise, a small number of educational areas account for the vast majority of educational virtual reality implementations that can be identified in the literature (Kavanaugh et al, 2017). In education, science and mathematics tend to see a broader adoption as they involve the study of natural phenomena and abstract concepts (Strangman & Hall, 2003). For example, Southern New Hampshire University piloted the use of VR in an undergraduate Psychology class in a 2020 pre-pandemic study that sought to understand the interchange between neural communication and behavior (Flynn & Frost, 2021).

With regards to the types of VR applications used in secondary and postsecondary institutions, there are two main categories. The first is where teachers use pre-developed applications to present or reinforce topics in class and the latter finds the students themselves creating virtual environments in order to test hypotheses or undergo experiential learning. Pre-developed applications generally consist of a virtual environment where a student completes a specific learning activity or task, such as in ScienceSpace or Maxwell World. These applications represent the broadest integration of VR in education as they are designed to support topics in the sciences (Christou, 2010). However, other fields where applications have been developed are in Cultural Heritage and Archeology (Pujol, 2004). Learning Sites has developed several desktop applications that allow students to explore archeological reconstructions of sites and structures. REVEAL is another software program that allows the 3D re-creations of ancient sites, buildings, and artifacts (Sanders, 2014).

Greater interest has been seen in arts and culture as of late, thanks largely to the digital humanities. The ability to model sites, such as historical cities, that cannot be visited, or the ability for students to immerse themselves in a foreign culture has immediate application in the humanities. However, researchers continue to grapple with when, how, where, and why IR should be integrated into educational curricula. While research is limited, the studies that do discuss the increasing adoption of VR in postsecondary art history programs date over the last twenty years and can be broken into five phases. The phases of integration run parallel to other advancements in smartphones and gaming that use motion sensor technology and touchscreens. In 2001, researchers began digitizing cultural heritage sites (both extant and ancient), although these projects were primarily restricted to specialists. Between 2001 and 2010, various museums began integrating VR experiences for "edutainment" purposes. 2011 saw the launch of full virtual museums and Google's Arts and Culture. Several games were developed the same year to assist in engagement, immersion and content retention with the gamification of art history. Finally, over the last three years (2017-2020), an increasing number of sites have been mapped, resulting in full virtual tours possible of UNESCO World Heritage Sites and the digitization of museum collections.

Virtual Reality in the Art World

Before the widespread development of virtual learning environments, such as virtual museums (VM), immersive technologies were first adopted to augment exhibitions in the physical museum space for edutainment. The possibilities of new VR technology to connect with a modern audience and expand cultural awareness was not lost on museum curators. But as Carrozzino and Bergamasco (2010) noted in their study, in the first decade of the twenty-first century, there were very few immersive installations as the technology was not widely understood or available to curators. Roussou (2001) related how the technology would be ideal for museums to adopt from the virtual environments created by the Foundation of the Hellenic World (FHW), a cultural heritage institution in Athens. Using the CAVE technology used by FHW, a digital reconstruction of ancient cities began with Miletus, an Athenian and later a Roman colony on the coast of Asia Minor (Tzortzaki, 2001). Other examples can be found in Austria (Ars Electronica, http:www.aec.at) and Japan (Intercommunication Centre, http:// www.ntticc.or.jp/). The potential for use of these emerging technologies for cultural heritage institutions was thus clear, but widespread adoption of the technology developed slowly.

Since then, several museums, including The Museum of Pure Form and The Virtual Museum of Sculpture, have been dedicated to immersive reality. The reasons for the adoption of AR and VR, Carrozzino and Bergamasco note, relates to the acceptance and availability of similar technology among the general public, including Nintendo's Wii (released 2006) with motion sensors, and the iPhone (released 2007) with touch screens and camera-based applications. Familiarity with similar technology made the public less hesitant to try VR installations. The results of these early virtual museums and exhibition spaces are significant for the applications we see now. For instance, unlike VR for the medical field or sciences, where users had to have a great deal of training to operate, these were designed for the general public who had little to no experience operating very complex hardware. Moreover, unlike the longer experiences designed by Salzman, Dede, Loftin and Chen, those for museums were necessarily short in duration to keep people moving through galleries. The experiences tied to physical spaces quickly led to fully virtual museums, such as The Exploratorium, a public science museum, and The CREATE project, an EU funded project that allows users to reconstruct archeological sites. These examples have seen the VR experience removed from the physical space of the museum and into the virtual arena (Christou, 2010). The need for a user-friendly interface and immersive design, coupled with shorter durations of the experience, has led to the design of VLE that are popular today.

Creating VLE has become a widely adopted way to teach Art History through either digitizing real museums or creating computer-generated versions. With the launch of Google's Arts & Culture in 2011, virtual visits to museums through AR/VR broke into the mainstream and is now accessible to anyone with a smartphone. With the addition of Google Cardboard, the head-mounted-display further democratizes the technology. Similar VLEs have been developed to tour real or virtual museums (VM) (Clini, Ruggieri, Angeloni, & Sassob, 2018). Others include the National Archeological Museum of Marche in Ancona and the 3D reconstruction of the Roman Forum from digitized photographs that first use movement metrics of technique-structure that are then uploaded to virtual environments with the HTC Live system (Favro, 2006). Two virtual environments that have applications built for the Samsung Gear VR system include the Rijksmuseum in Amsterdam, and a virtual recreation of the city of Gyeongju, South Korea. Other experiences have been developed with free game engines, such as Unity3D, to create a virtual museum for students to tour. Brennan and Christiansen (2018), for instance, digitized ancient sculpture collections using 3D scanners and high-quality photography that were imported into Unity to create an immersive experience. The Universidad Nacional de San Agustin de Arequipa in Peru likewise developed an experience for their art history students in Unity. As noted above, the active learning strategy had positive results when studying the perceptions of students and the outcomes for the experience (Huaman, Aceituno & Sharhorodska, 2019).

The virtual museum also provides an example of the gamification of VR where students move through each room of the museum and get points per room and for engaging with the works in each. The survey data collected from students demonstrated that the experience improved student outcomes, but also revealed that greater interactivity and engagement would result from allowing students to create their own exhibitions. Developers like VIVE have since capitalized on the results and released VIVE Arts, which enables users to both create and exhibit works of art within a virtual space. Since 2016, the Venice Biennale and International Film Festival holds the Venice VR, the official VR competition associated with the annual event, which showcases work in this new medium.

Most recently, Brown edited a volume on digital humanities and art history that addresses virtual museums (2020). Collections and whole museums are being digitized for viewing in AR/VR at an accelerated rate. For instance, since 2006, the Center for the Art of East Asia in the Department of Art History, Division of Humanities, at the University of Chicago (CAEA) has developed the digital technologies necessary for archiving and viewing collections of East Asian paintings and sculptures. These include The Scroll Paintings Project and The Chinese Buddhist Caves Temple Projects, which aim to increase access to art-historical resources to foster collaboration and scholarship with works that are often inaccessible. However, museums can only digitize so quickly on their own, so many are now leveraging service-orientation to assist in creating their own virtual museums. Using open-source technologies, such as a bespoke application interface (API), allows third parties like "app communities" to recreate a collection or assemble artworks and create a new virtual museum.

Virtual Reality in Art History Education

With the ability to effectively transport students to any site in the world, including world culture heritage locations and museums, IR are ideally suited for digital humanities and Art History departments. In fact, the field has always readily adopted new technologies to study cultural artifacts. From illustrating works through printmaking to projecting photographs with a magic lantern to the slide projector carousels that preceded the ceiling mounted LCD projectors that predominate the classrooms of today, Art History has continuously sought ought immersive ways to bring works of art and famous monuments to students. Moreover, the benefits of these technologies for digital humanities and for preserving, representing, and then disseminating monuments and works of art has seen a great deal of attention as of late (Addison & Gaiani, 2000; Papagiannakis, Geronikolakis, Pateraki, López-Menchero, Tsioumas, & Sylaiou, 2008; Adhani & Rambli, 2012; Anthes, García-Hernández, Wiedemann, & Kranzlmüller, 2016; Bekele et al., 2018). Unlike the earlier technologies used in the discipline, which were primarily passive in their delivery of information and imagery, VR has the ability to dynamically engage students and educators in a simulacrum. As Bekele and Champion (2019, p.31) outline, the technology has three characteristics that act in concert to provide an experience that has the potential to: "(1) establish a contextual relationship between users, virtual content, and cultural context, (2) allow collaboration between users, and (3) enable engagement with the cultural context in the virtual environments and the virtual environment itself." In other words, students are able to engage not only with the material, other students and their instructor, but also to understand the context of those relationships while immersed in the virtual environment.

Returning to the use of VR in education, the virtual museum developed by Huaman, Aceituno and Sharhorodska demonstrate the benefits of gamification in the field. Froschauer, Arends, Goldfarb, and Merkl (2011) argued for similar benefits with their online multiplayer Serious Game *ThIATRO*. The prevalent methods for teaching in the field of Art History can often be seen as tedious to students with regards to the sheer amount of information to memorize and contextualize within various cultures. At the same time, having the background in culture and history provided by art history supports a raising of awareness in students for contemporary culture. In order to engage current digital natives, the multiplayer game seeks to engage students in a playful manner to increase motivation and learning outcomes. Like other games, such as *ARTé: Mecenas, ThIATRO* compels the player to think about, organize and use information in ways that encourage active construction of knowledge, as well as to collaborate with others. Another project by Casu, Spano, Sorrentino and Scateni (2015) sought to leverage the lower cost of consumer hardware in developing an application for the teaching of Art History. *ArtRift* is a VR tool designed for art history students and teachers which allows the configuration of virtual museum rooms with artworks that can be enhanced with multimodal annotation. As with a traditional art history lecture, works of art are juxtaposed with each other in each room and instructors add additional multimedia content, such as audio or textual descriptions. The benefits of such virtual museums and flexible selections, as noted by Casu, Spano, Sorrentino, and Scateni, is that works located in different spaces, such as Michelangelo's *David* and *Moses* can be brought together into one virtual environment for comparison. With VR, students can compare the physical elements of works of art (texture, scale, size, orientation, etc.) as they could not previously. Students at Filippo Figari High School in Sassari were then either given access to the VR application or saw the same environment projected onto a wall. At the end of the course, participants were given the Instructional Material Motivation Survey instrument (IMMS) to assess the effectiveness of the experience. The qualitative aspects surveyed were: Attention Factor, Satisfaction, Relevance. Motivation was notably improved through the use of the VR *ArtRift* tool in delivering course content.

As noted above, there has been ample research conducted on the use of VR for industry and K-12 education, but little for higher education (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Brownridge (2020), for instance, recently published a study of VR integration into history and social studies for secondary education. Students were taken on virtual field trips using Google Expedition (GE) and saw a dramatic improvement with regards to motivation and engagement. Ghida's 2020 article represents a rare example of AR/VR being used in higher education curriculum. In his History of Western Architecture class, Ghida demonstrates one of the most impactful uses of immersive realities: the ability to study a three-dimensional monument in three dimensions. While not a qualitative study, the examples provided by Ghida to better prepare architecture students with the tools and skills they will need in their careers, as well as a summary of what other institutions are currently doing to integrate IR into curriculum, is useful to contextualize our own study. Specifically, the use of Google Earth VR (released 2017) (a precursor to Wander released 2019) to experience monuments virtually in human scale has immediate application in the field of Art History. Ghida's compelling argument is that the traditional way most college courses are taught, including the visual arts and architecture, still rely on lecturing with PowerPoint presentations as visual aids. While the technology has proven useful for two-dimensional subjects to be critically evaluated and analyzed, the same cannot be said for those that are three-dimensional. It is no surprise then that the approach has been adopted predominantly in departments of architecture around the world, including Utah State University, MIT, Queensland University of Technology, Georgia State University, University of South California, The Chinese University of Hong Kong, Mount Saint Mary College, NY, and Florida State University.

While using VR to visit sites around the globe is immediately applicable to teaching subjects like architecture, other research has demonstrated that much like the use in the sciences and mathematics to understand abstract concepts, the technology can also assist in an understanding of chronology. Korallo (2010) conducted a study of three groups of students in the United Kingdom and the Ukraine at three levels- elementary school, middle school, and undergraduate students- to determine the effectiveness of using Virtual Environment (VE) to assist in the understanding of historical chronology in a number of fields. The study found that the abstract nature of time and chronology makes comprehension difficult, especially for middle school students. The three groups learned sequences of events using virtual environments. At the same time, control groups were shown only text, pictures, and PowerPoint slides, though they were the same sequence of events. Two series of parallel timelines were experienced in tandem that included music and art history, as well as the history of psychology, art and general history. A substantial benefit was seen when undergraduates used a large spatial environment which allowed them to view across all three parallel timelines. The research concluded that using virtual environments to understand how events unfold in time does in fact yield better results in internalizing chronology when compared to other non-immersive media. The results were replicated more recently in the design department of a Southern Chinese university with an additional 70 students. The study of using VR to teach design history concluded that "compared with traditional teaching, virtual reality learning system significantly improves students' learning attitudes" (Wu, 2020, p.284).

A similar experience was developed at the University of Indiana, Bloomington for a Renaissance Art History class in 2018. Brennan (2018) in collaboration with Dr. Giles Knox developed four thematically linked fresco cycles in the Unity game engine. Outside of class time students used the HTV Vive headsets in the campus Virtual Reality Lab to explore one fresco cycle at a time, starting with the Scrovegni Chapel in Padua, Italy. High-quality 360 photographs were used and imported into the game engine and the built environment. Students could move through the space by teleporting to various nodes and listen to Smarthistory lectures covering different scenes as they approached them in the virtual environment. The process involved many iterations and playtesting to ensure the best experience for users and to reduce VR sickness. In a novel addition, a scaffolding was added to allow for direct inspection of the frescoes at eye-level as though hovering in the air, a view that would be impossible in person.

Libraries such as that at the University of Calgary and the University of Oklahoma have begun expanding into services that include VR as early as 2016. Carts with VR headsets are becoming standard sites in classrooms and shared learning spaces. Hurrell and Baker (2020) provide an overview of the uses of VR at their institution, including in art history. Undergraduate classes often scheduled drop-in lab visits to supplement material covered in traditional lectures. Examples include virtual field trips using Google Earth VR to explore real life locations without having to fund expensive travel. Other uses can be found in German language classes touring historic locations, a Women's studies class studying the Stonewall Riots touring Greenwich Village, and Classics classes touring the Parthenon and other ancient Greek monuments. The restrictions noted include the large size of undergraduate classes and the limited number of headsets available for each student to use.

Varnum likewise noted similar use at the University of Oklahoma library system (2019). Primarily serving researchers in engineering, architecture, archaeology, and anatomy, the library also has services for students to use HDMs and has invested in services to catalog and preserve older applications. The librarians also work directly with faculty to design assignments that will best utilize VR technology. An example of class use can be found in the partnership with the Anthropology Department. In fall 2017, students in an introductory undergraduate anthropology class visited the VR facilities in the library to examine hominid skull models. In preparation, emerging technology librarians worked with the course instructor to develop a course assignment that would leverage the documented benefits of the VR platform in support of the learning objectives of a particular course module. The questions in the assignment required the students to search for specific features on a virtual Homo heidelbergensis cranium, describe the structural changes evident in chronologically ordered fossils, and analyze specific skull features in order to determine diet. To evaluate the benefits of VR for student learning, the authors collected data in the form of pre- and post-surveys and semi-structured interviews with students following the completion of the assignment. Initial analysis of the data collected suggests an improvement in students' self-efficacy in regard to their ability to carry out spatial analysis tasks.

The main motivations for the adoption of immersive reality technology in education are supported by research in improving student motivation, engagement, and outcomes. The primary obstacle for the average educator is the start-up cost of obtaining and being trained on the new technology, understanding how to leverage new and existing applications to support various coursework, and ensuring students have adequate access to both hardware and software. The barrier was clearly outlined by Kavanaugh et al. (2017) as they summarized the difficulties in adopting VR for distance education and noted that designing educational systems around any kind of specialized hardware will render them unsuitable as a distance learning tool. The reason for this is that all participants (both students and teachers) would need the HMD, which has heretofore been cost prohibitively expensive. As such, Kavanaugh et al. conclude that "Even if the upcoming iteration of VR HMDs are relatively popular among consumers, such an approach would still likely end up excluding students" (2017, p.108). Despite past limitations, research has demonstrated the viability of immersive realities in teaching art history in many areas. For instance, paintings can be compared and contrasted in virtual museums, famous monuments can be visited and interacted with, class lectures can be held in virtual museums and virtual classrooms, and historical context and chronology can be more readily learned through visual orientation and understanding events as physical spaces.

METHODLOGY

Summary of Methods

The study under review here had two primary initiatives. The first sought to investigate the perceived educational benefits and technical and pedagogical challenges of using VR technology from both student and faculty perspectives. The second sought to identify the best strategies for how and when to incorporate VR technology into postsecondary curriculum. Qualtrics was utilized to disseminate our surveys, and results were collected in May 2021. Students in online and hybrid courses in the Department of Art History and Visual Culture were surveyed regarding their experiences over the 2020-2021 academic year. Two faculty representatives from each school (totaling 12) across the University were surveyed for this same period. Demographic data, including first-generation status, age, gender, race and ethnicity, and major was collected from students. Students were also asked if they were taking the course to fulfill a general education or major requirement, about their familiarity with VR technology, potential complications with use, which VR experience they completed, if it was for course credit or extra credit, and their perceived usefulness of the experience compared to learning activities utilizing other media. They were then asked to the usefulness of VR technology for achieving learning goals, and if they would wish to use VR technology in more courses. The purpose of the faculty survey was to understand the challenges of integrating this technology into various fields of study. Demographic information, including race and ethnicity, gender, and age was also gathered from faculty participants. They were likewise surveyed regarding their familiarity with VR technology, potential complications with use, and their likelihood to use this technology in their field. Finally, the surveys for both students and faculty concluded with an open-ended question asking for any further considerations regarding VR adoption.

Analysis of Results

Student VR Familiarity Survey

Before circulating the May 2021 survey, a preliminary study collected data from 128 students across the Division of Art and Design. The survey was only completed by students to gauge their familiarity and perceptions of immersive realities for their given disciplines. Results indicate that most students are aware of the technology, but few had actual experience. Students were first asked about their familiarity with virtual reality technology. Of the 128 respondents, 46 (35.9%) said that they were moderately familiar with the technology, but 33 (24.7%) said they were not familiar at all. 75% have at least some exposure or familiarity according to the survey with the technology.

To determine viable strategies for VR integration, students were surveyed on the devices they already possessed. Not only is Google cardboard the most inexperience foray into VR, but the new all-in-one headsets also require a mobile device for set up. As such, students were asked if they owned a smartphone or a tablet and only 1 said they did not either own either an Apple or an Android device. 94 said they owned an Apple and 31 an Android device. The application of question informed us that we could begin assigning tasks to be completed via Google Cardboard, and that students would be able to download required applications necessary for certain Oculus headsets. The approach was confirmed as most viable when students were asked if they currently owned a VR headset, and out of 128, 106 responded that they did not, whereas 10 own Google cardboard, 3 own Oculus Rift, 5 own PlayStation VR, 2 Oculus Quest, and 2 Oculus Quest 2. In all, most students in postsecondary programs have devices to start learning in VR even without institutional investment.

Finally, students were queried on their desire to use the technology as part of their education and understanding of its importance in their industries. Students were asked if they would like to see more immersive reality (AR/VR) activities/experiences integrated into their coursework. Out of the 128 students, 51 responded in the affirmative, 52 with neutral and 25 responded in the negative. While the results showed greater hesitancy to fully adopt the technology for teaching and learning, students agreed how important learning the technology would be to their future careers. Of the 128 students, 80 responded in the affirmative, 38 responded maybe, and 9 responded in the negative. The survey concluded by asking how likely respondents would be to purchase a headset, using Oculus Quest 2 as a starting point for cost at $299. Out of 128 students, 43 responded that they would be very unlikely to purchase one, 33 said somewhat unlikely, somewhat likely 27, 15 were neutral and extremely likely at 10. The results of the initial survey confirm that students: are familiar with the technology, though have not experienced it; have the necessary hardware to adapt to using without significant investment; want to see it in their education and understand the importance for their future professions, but are generally unwilling to invest their own resources into acquiring stand-alone hardware themselves.

Student VR Course Survey

Following the initial survey, assignments using VR were included in all art history classes and select art and design courses Spring 2021. The classes were eight weeks in duration and students were surveyed at the end of each. Of the 23 student respondents surveyed, 17 were undergraduates and 6 graduate students. The majors represented were as follows: Art History and Visual Culture (6), Art or Gaming and Design (6), Business Administration and/or Sports Management (3), Healthcare Management (2) Accounting (2), and 4 other miscellaneous majors (Criminology, Social work, Cyber security, and Marketing.) 15 of the participants were 34 or younger. 78% identified as female, 81% identified as white, and only one participant indicated that they were a first-generation student. Concerning exposure to Virtual Reality technology before the term, 83% reported that they ranged between “slightly familiar” (13) to extremely familiar (2), but only 53% had used a VR headset or program.

The most important data gathered from the student surveys regards the students’ perception of usefulness and benefit of VR activities. 74% of students felt that VR assisted in their learning, while only 3 (12%) of the 23 participants disagreed with its usefulness. 75% of the participants found that it was more useful to learn about the assigned topic through a VR experience than by reading about it. 65% of the students stated that would recommend the activity to other students, and over half of respondents reported that they would like to see this technology used in other courses. At minimum, only 3 students (13%) indicated that the technology was frustrating or inhibited their learning, while 5 more were neutral, and 15 reported that it did not negatively impact their learning.

One of the positive implications for the use of VR technology is that the majority of students did not report any start up difficulty. 83% reported that launching the technology or getting started into the assigned application was either neutral or easy. And only two respondents state that the physical apparatus of the VR devices were difficult to interact with. Of the other 20, 6 found it somewhat difficult, and 14 did not have an issue.

Faculty Survey

The faculty members who were surveyed were all full-time employees, and represented the following five colleges: Arts, Media, and Communications, Education, Sciences, Health Sciences, and Humanities. Of the 8 faculty respondents, 7 indicated that using the Oculus Quest 2 headset was extremely easy. The crucial insight this survey provided is that all respondents stated that using VR technology in their classroom would be moderately to extremely useful. They all also reported a general support for the adoption of VR technology in their classrooms. The difficulty, however, is that aside from one participant, all faculty members either reported that finding relevant applications for their field was neutral, or somewhat or extremely difficult. Their comments reflected the same sentiment—many reported that the current app store for the Oculus 2 either did not include free relevant applications, or that they were not easy to locate. One respondent commented that the program they would use included a costly subscription service. The general consensus was that there was a great deal of potential for this technology, but currently, most of the educational programs were better suited for K-12 use. They also recommended a “buy not build” strategy for initial adoption. This would give students exposure to assignments and allow them to acclimate to the technology and potential VR sickness. With time, several respondents also reported a desire or need to become involved in content development to make applications related to their fields.

CONCLUSION

The results of the study support the findings of previous studies and demonstrates the positive correlation between the use of immersive technology and positive outcomes such as increased excitement for the learning process, motivation, deeper learning, and long-term retention. Students reported deeper learning as opposed to other media or engagement strategies. In order to build on the results of this study and adopt as a model for other institutions the following recommendations should be considered. Provide professional development for faculty and students to lower the barriers to entry, including training, examples, templates, sample assignments, etc. Be flexible in designing learning options for students, such as giving multiple applications as options per unit that can be selected from. Make learning exciting and build community by having students engage with each other, find new apps to share with one another and create a Discord or other social media space for students to share their experiences and recommendations with each other. Finally, one of the major outcomes from the study is that at a baseline, students and faculty members are not opposed to the use of VR technology. While a portion of respondents reported a neutrality towards the technology, the majority of those polled reported a willingness to engage with VR tech on more assignments, or to utilize it in their classrooms. But beyond just indicating a general openness to the use of VR tech, these results demonstrate that its use can have some very beneficial outcomes, which should be encouraging to more educators both in Art History and beyond for its adoption.

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REFERENCES

Addison, A., & Gaiani, M. (2000). Virtualized architectural heritage: New tools and techniques. *IEEE MultiMedia*, *7*, 26–31.

Adhani, N.I., & Rambli, D. (2012). *A survey of mobile augmented reality applications*. Paper Presented at the 1st International Conference on Future Trends in Computing and Communication Technologies (Malacca).

Anthes, C., García-Hernández, R.J.G., Wiedemann, M., & Kranzlmüller, D. (2016). *State of the art of virtual reality technology*. Paper Presented at the Aerospace Conference, 2016 IEEE (Big Sky, MT).

Apostolellis, P., & Bowman, D. (2014). Evaluating the effects of orchestrated, game-based learning in virtual environments for informal education. *Proceedings of the 11th Conference on Advances in Computer Entertainment Technology - ACE* '14, pp. 1–10. New York, USA: ACM Press.
Bandyopadhyay, S., & Bandyopadhyay, K. (2015). Factors Influencing Student Participation In College Study Abroad Programs. *Journal of International Education Research (JIER), 11*(2), 87–94.
Bekele, M., & Champion, E. (2019, September). A Comparison of Immersive Realities and Interaction Methods: Cultural Learning in Virtual Heritage. *Front. Robot. AI*, *24*, 91.
Bekele, M., & Champion, E. (2019). *Redefining mixed reality: User-reality-virtuality and virtual heritage perspectives*. Paper Presented at the Intelligent & Informed, Proceedings of the 24th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA). Wellington, New Zealand.
Bekele, M., Pierdicca, R., Frontoni, E., Malinverni, E., & Gain, J. (2018). A survey of augmented, virtual, and mixed reality for cultural heritage. *J. Comput. Cult. Herit*., *11*(7).
Biocca, F., & Levy, M. (1995). *Communication in the Age of Virtual Reality*. Lawrence Erlbaum Associates, Hillsdale, New Jersey.
Bowman, D., Hodges, L., & Wineman, J. (1998). *The educational value of an information-rich virtual environment* (GVU Technical Report; GIT-GVU-98-05). Atlanta: Georgia Institute of Technology.
Boyles, B. (2017). *Virtual Reality and Augmented Reality in Education.* United States Military Academy, West Point, New York.
Brown, K. (Ed.). (2020). *The Routledge Companion to Digital Humanities and Art History*. Routledge.
Brownridge, P. (2020). *A Place in History: Virtual Reality in Secondary Education.* [Dissertation]. Rowan University.
Brennan, M. (2018). *Virtual Reality in the Humanities Classroom*. University of Indiana, Bloomington.
Brennan, M., & Christiansen, L. (2018). Virtual Materiality: A Virtual Reality Framework for the Analysis and Visualization of Cultural Heritage 3D Models. *Digital Heritage*.
Carrozzino, M., & Bergamasco, M. (2010). Beyond virtual museums: Experiencing immersive virtual reality in real museums. *Journal of Cultural Heritage*, *11*(4), 452–458.
Casu, A., Spano, L., Sorrentino, F., & Scateni, R. (2015). RiftArt: Bringing Masterpieces in the Classroom through Immersive Virtual Reality. Biasotti, Silvia & Tarini, Marco (Eds.), *STAG: Smart Tools & Apps for Graphics* (pp. 77–84).
Chen, C.J. (2006). The design, development and evaluation of a virtual reality based learning environment. *Australasian Journal of Educational Technology*, *22*(1), 39–63.
Cheung, S., Fong, J., Fong, W., & Wang, F.L. (Eds.). (2013). *Hybrid Learning and Continuing Education* (Vol. 8038). Berlin, Heidelberg: Springer.
Christou, C. (2010). Virtual Reality in Education. In A. Tzanavari & N. Tsapatsoulis, *Affective, interactive and cognitive methods for e-learning design: Creating an optimal educational experience* (pp. 228–243).
Clini, P., Ruggieri, L., Angeloni, R., & Sassob, M. (2018). Interactive immersive virtual museum: Digital documentation for interaction. In *ISPRS TC II Mid-term Symposium Towards Photogrammetry* (pp. 251–257).
Dalgarno, B., Hedberg, J., & Harper, B. (2002). The contribution of 3D environments to conceptual understanding. In *Proceedings of the 19th Annual Conference of the Australian Society for Computers in Tertiary Education (ASCILITE).* Auckland, New Zealand: UNITEC Institute of Technology, Auckland, New Zealand.
Doyle, D. (2017). Avatar Lives: Narratives of Transformation and Identity. In J. Gackenbach & J. Brown (Eds.), *Boundaries of Self and Reality Online: Implications of Digitally Constructed Realities* (pp. 57–74). Academic Press.
Dunaway, K. (2011). Connectivism: Learning theory and pedagogical practice for networked information landscapes. *Reference Services Review*, *39*(4).
Earnshaw, R.A., Gigante, M. & Jones, H. (Eds.). (1994). *Virtual Reality Systems.* Academic Press.

Ertmer, P., & Ottenbreit-Leftwich, A. (2010). Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. *Journal of Research on Technology in Education*, *42*(3), 255–284.
Ettlinger, O. (2009). *The architecture of virtual space*. Ljubljana, Slovenia: University of Ljubljana Faculty of Architecture.
Favro, D. (2006). In the Eye of the Beholder: VR Models and Academia. In L. Haselberger & J. Humphrey (Eds.), *Imaging Ancient Rome: Documentation, Visualization, Imagination: Proceedings of the Third Williams Symposium on Classical Architecture* (pp. 321–34). Portsmouth, RI: Journal of Roman Archaeology.
Ferracani, A., Pezzatini, D., & Bimbo, A. (2014). A natural and immersive virtual interface for the surgical safety checklist training. In S. Göbel & W. Effelsberg (Eds.), *Proceedings of the 2014 ACM International Workshop on Serious Games* (pp. 27–32). New York, USA: ACM Press.
Flynn, C., & Frost, P. (2021). Making VR a Reality in the Classroom. *EDUCAUSE Review*. Retrieved April 21, 2021, from: https://er.educause.edu/articles/2021/4/making-vr-a-reality-in-the-classroom?utm_source=Selligent&utm_medium=email&utm_campaign=er_content_alert_newsletter&utm_content=04-21-21&utm_term=_&m_i=B6iZv6R%2BN1IzGiAxuhXiAxP1deggx04rHO1BRPA0RGL2dz57iAaHm8cI%2BXdv8QKuAX0%2BdpZgAgdDw1vUCySi678xKg4dRzQBB2&M_BT=15676450034
Frischer, B. (2009). Art and Science in the Age of Digital Reproduction: From Mimetic Representation to Interactive Virtual Reality. *Virtual Archeology Review*, *2*(4), 19–32.
Froschauer, J., Arends, M., Goldfarb, D., & Merkl, D. (2011). Towards an Online Multiplayer Serious Game Providing a Joyful Experience in Learning Art History. *Third International Conference on Games and Virtual Worlds for the Serious Applications*.
Ghida, B. (2020). Augmented Reality and Virtual Reality: A 360° Immersion into Western History of Architecture. *International Journal of Emerging Trends in Engineering Research*, *8*(9), 6051–6055.
Grau, O. (1999). Into the Belly of the Image: Historical Aspects of Virtual Reality. *Leonardo, 32*(5), 365–371.
Grau, O. (2003). *Virtual art: From illusion to immersion*. Cambridge, MA: MIT Press.
Horowitz, K. (2004). *Sega VR: Great Idea or Wishful Thinking?* Retrieved May 19, 2015, from http://web.archive.org/web/20100114191355/http://sega-16.com/feature_page.php?id=5&title=Sega
Howard, S., & Mozejko, A. (2015). Teachers: technology, change and resistance. In M. Henderson & G. Romeo (Eds.), *Teaching and Digital Technologies: Big Issues and Critical Questions* (pp. 307–317). Port Melbourne, Australia: Cambridge University Press.
Hsieh, P., Wu, Y., & Ma, F. (2010). A study of visitor's learning needs and visit satisfaction in real and second life museums. In T. Hirashima, A.F. Mohd AYUB, l. Kwok, S. Wong, S.C. Kong, & F. Yu (Eds.), *Workshop Proceedings of the 18th International Conference on Computers in Education* (pp. 248–255).
Huaman, E.M.R., Aceituno, R.G.A., & Sharhorodska, O. (2019). Application of Virtual Reality and Gamification in the Teaching of Art History. In P. Zaphiris & A. Ioannou (Eds.), *Learning and Collaboration Technologies. Ubiquitous and Virtual Environments for Learning and Collaboration* (pp. 220–229). HCII 2019. Lecture Notes in Computer Science, vol 11591. Springer, Cham.
Huang, H., Rauch, U., & Liaw, S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education*, *55*(3), 1171–1182.
Hurrell, C., & Baker, J. (2020). *Immersive learning: Applications of virtual reality for undergraduate education*. College and Undergraduate Libraries. Taylor & Francis.
Hussein, M., & Nätterdal, C. (2015). *The Benefits of Virtual Reality in Education A Comparison Study.* Department of Computer Science and Engineering. Chalmers University of Technology University of Gothenburg, Göteborg, Sweden.

Jacobson, J., & Holden, L. (2005). The Virtual Egyptian Temple. *Proceedings of the World Conference on Educational Media, Hypermedia & Telecommunications (ED-MEDIA)*. Retrieved December 20, 2017, from https://pdfs.semanticscholar.org/e4cb/929440177f9ea9a87ac5eacb6f4f33977e98.pdf

Johnson, A., Roussos, M., Leigh, J., & Vasilakis, C. (1998). *The NICE Project: Learning Together in a Virtual World*. Retrieved December 20, 2017, from http://evlweb.eecs.uic.edu/aej/papers/vrais98.pdf

Jones, S. (2000). Towards a Philosophy of Virtual Reality: Issues Implicit in "Consciousness Reframed". *Leonardo*, *33*(2), 125–132.

Kauhanen, O., Väätäjä, H., Turunen, M., Keskinen, T., Sirkkunen, E., Uskali, T., . . . Karhu, J. (2017, September 20–21). Assisting immersive virtual reality development with user experience design approach. *AcademicMindtrek'17*, pp. 127–136. Tampere, Finland.

Kavanaugh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of Virtual Reality in education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Kolb, A., & Kolb, D. (2012). Experiential learning theory. *Encyclopedia of the Sciences of Learning*, pp. 1215–1219. Springer.

Korallo, L. (2010). *Use of virtual reality environments to improve the learning of historical chronology*. [PhD Thesis]. Middlesex University, London.

Krause, S. (2000). "Among the Greatest Benefactors of Mankind": What the Success of Chalkboards Tells Us about the Future of Computers in the Classroom. *The Journal of the Midwest Modern Language Association*, *33*(2), 6–16.

Kushner, D. (2014). Virtual reality's moment. *IEEE Spectrum*, *51*(1), 34–37.

Le, Q., Akeem, P., & Chan, S. (2014). A social Virtual Reality based construction safety education system for experiential learning. *Journal of Intelligent & Robotic Systems*, *79*(3–4), 487–506.

Lee, E., & Wong, K. (2008). A Review of Using Virtual Reality for Learning. *Transactions on Edutainment*, pp. 231–241.

Licastro, A., Nieves, D., & Szabo, V. (2020). The Potential of Extended Reality: Teaching and Learning in Virtual Spaces. *The Journal of Interactive Technology & Pedagogy*, p.17.

Lindstrand, T. (2007). Viva piñata: Architecture of the everyday. In F. von Borries, S.P. Walz, & M. Böttger (Eds.), *Space time play: Computer games, architecture and urbanism: The next level* (pp. 354–357). Basel, Switzerland: Birkhauser.

Ma, J., & Choi, J. (2007). The Virtuality and Reality of Augmented Reality. *Journal of Multimedia*, *2*(1), 32–37.

McLellan, H. (1996). Virtual realities. In D.H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology*. New York: Macmillan Library Reference, USA.

McLellan, H. (2003). Virtual realities. In D.H. Jonassen & P. Harris (Eds.), *Handbook of Research for Educational Communications and Technology* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.

Merchant, Z., Ernest, Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in k-12 and higher education: A meta-analysis. *Computers & Education*, *70*(0), 29–40.

Moorefield-Lang, H. (2015). Libraries and the Rift: Oculus Rift and 4D Devices in Libraries. *Knowledge Quest*, *43*(5), 76–77.

Otto, P. (2009, May). Romanticism, Modernity, and Virtual Reality: An Overview and Reconceptualisation of the Field. *Australian Humanities Review*, *46*, 27–38.

Pantelidis, V. (2009). Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality. *Themes in Science and Technology Education*, *2*, 59–70.

Papagiannakis, G., Geronikolakis, E., Pateraki, M., Bendicho, V.M., Tsioumas, M., Sylaiou, S., . . . Thalmann, N. (2018). Mixed Reality Gamified Presence and Storytelling for Virtual Museums. In N. Lee (Ed.), *Encyclopedia of Computer Graphics and Games* (pp. 1–13). Cham: Springer.

Pope, H. (2018). Virtual and Augmented Reality in Libraries. *Library Technology Reports*, *54*(6), 1–25.

Prensky, M. (2001, October). Digital natives, digital immigrants. *On the Horizon*, *9*(5), 1–9.

Pujol, L. (2004). Archeology, Museums, and Virtual Reality. *Revista Digital d'Humanitats*, (6), 1–9.
Radianti, J., Majchrzak, T., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*.
Resnick, M., & Morgan, G. (2017). *Best Practices for Virtual Reality in Higher Education*. Gartner.
Rizzo, A., Bowerly, T., Buckwalter, G., Klimchuk, D., Mitura, R., & Parsons, T. (2006). A Virtual Reality scenario for all seasons: The virtual classroom. *CNS Spectrums*, *11*(1), 35–44.
Rose, M. (2018). Technologies of seeing and technologies of corporeality: Currents in nonfiction virtual reality. *World Records*, *1*, 11.
Roussou, M. (2001). Immersive Interactive Virtual Reality in the Museum. *Foundation of the Hellenic World*, *254*.
Salzman, M., Dede, C., Loftin, R, & Chen, J. (1999). A model for understanding how virtual reality aids complex conceptual learning. *Presence: Teleoperators and Virtual Environments*, *8*, 293–316.
Sanchez, A., Barreiro, J., & Maojo, V. (2000). Design of virtual reality systems for education: A cognitive approach. *Education and Information Technologies*, *5*, 345–362.
Sanders, D. (2014). Virtual Heritage: Researching and Visualizing the Past in 3D. *Journal of Eastern Mediterranean Archaeology & Heritage Studies*, *2*(1), 30–47.
Schroeder, R. (1993). Virtual reality in the real world: History, applications and projections. *Futures*, *25*(9), 963–973.
Schunk, D. (2012). *Learning theories an educational perspective.* Pearson.
Selverian, M. (2004). *Being there in the VLE: A pan-pedagogical model for enhanced learning through perceptual states of "presence"*. [Unpublished doctoral dissertation]. Temple University, Philadelphia, PA.
Sharma, S., Agada, R., & Ruffin, J. (2013). Virtual reality classroom as a constructivist approach. *Proceedings of the 2013 IEEE Southeastcon*, pp. 1–5. Jacksonville, FL, USA: IEEE. http://doi.org/10.1109/SECON.2013.6567441
Shepard, E. (1987). The magic lantern slide in entertainment and education, 1860–1920. *History of Photography*, *11*(2), 91–108.
Siemens, G. (2014). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning*, *2*.
Strangman, N., & Hall, T. (2003). *Virtual reality/simulations*. National Center on Accessing the General Curriculum, Wakefield.
Szymanski, M. (2018). Computer Games in Art History. Traditional architecture and painting presented in virtual reality. *E-Methodology*, *5*, 84–99.
Thomsen, C. (1994). *Visionary Architecture: From Babylon to Virtual Reality.* Prestel, New York.
Tzortzaki, D. (2001). Museums and virtual reality: using the CAVE to simulate the past. *Digital Creativity*, *12*(4), 247–251.
Varnum, K. (Ed.). (2019). *Beyond Reality: Augmented, Virtual, and Mixed Reality in the Library*. American Library Association.
Weise, M. (2020). *Long Life Learning: Preparing for the Jobs that Don't Even Exist Yet*. Wiley.
Wickens, C. (1992). Virtual reality and education. *[Proceedings] 1992 IEEE International Conference on Systems, Man, and Cybernetics* (vol. 1, pp. 842–847). Chicago, IL.
Wu, W. (2020). The Influence of Virtual Reality Learning System on the Learning Attitudes of Design History. *Proceedings of the 8th International Conference on Kansei Engineering and Emotion Research*, pp. 284–291.
Youngblut, C. (1997). Educational uses of virtual reality technology. Executive report. Reprinted from *Educational uses of virtual reality technology* (IDA Document Report Number D-2128). Alexandria, VA: Institute for Defense Analyses, 1998. VR in the Schools, *3*(1).