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Abstract

The technology of virtual reality (VR) has had proven educational benefits over the last three decades. Yet, most research conducted on these benefits has been confined to the sciences, especially in Computer Science. The application of VR technology for the Digital Humanities is only now beginning to receive attention, but more study needs to be conducted on its uses within various humanistic disciplines. In order to expand on the research at a pivotal time in education when modalities expand to incorporate more hybrid, distance education, and online learning, this study reviews the literature and theories behind the educational use of VR as a tool to reinforce learning outcomes in the field of art history. Through the review, theories and best practices are presented for practical adoption at various level of instruction at other institutions, as well as a list of recommendations for integrating VR technology specifically within art history instruction.

Introduction

Virtual reality (VR) has been used in applied fields since the 1960s in flight simulators for the military and industry training (Schroeder, 1993; McLellan, 1996; Boyle, 2017). Youngblut (1997) also conducted a review of the use of virtual reality and its effectiveness in K-12 education in the 1990s. Salzman, Dede, Loftin, and Chen (1999) followed the study with a framework for understanding how virtual reality supports conceptual learning. Supported by earlier studies, the results confirm the virtual immersive environment leads to positive learning outcomes by providing easy associations between symbolic and experiential information (Bowman, Hodges, Allison, & Wineman, 1998). Additionally, Dalgarno, Hedberg, and Harper (2002) point to perhaps one of the most significant contributions of virtual reality - 3D learning environments (3DLEs). The technology facilitates spatial knowledge development with regards to a subject.

Even though there is clear applicability to other fields, the technology persists in being predominantly adopted in applied fields (such as natural sciences, health care, and the military) and for training. As such, a relatively limited number of educational areas account for the vast majority of educational virtual reality implementations that can be identified in the literature (Kavanagh, Luxton-Reilly,, Wuensche, & Plimmer, 2017). In education, science and mathematics retains the broadest application since these often involve the study of natural

phenomena and abstract concepts (Strangman & Hall, 2003). As of late, however, greater interest has been seen in the fields of arts and culture, thanks largely to the Digital Humanities. The ability to digitally reconstruct historical sites, such as archeological sites or cities, visit remote locations or museums, or be immersed in a foreign culture all have direct application to humanities disciplines, especially art history. Despite these possibilities, there have only recently been studies on the practical applications of VR in art history in examples such as virtual exhibitions and/or museums, video games, and virtual tours of sites around the globe.

In order to expand the research on the integration of VR technology into art history as a tool to reinforce learning outcomes, this study seeks to provide a review of the literature on the theories and best practices through the present. In this review, theories and best practices are presented for practical adoption at various levels of instruction at other institutions.

Literature Review

Previous research has found a positive correlation between the use of immersive technologies and learning. Specifically, Johnson, Roussos, Leigh, and Vasilakis (1998) related higher scores for time-on-task, Apostolellis and Bowman (2014) noted the increased enjoyment of learning by students, Cheung, Fong, Fong, Wang, and Kwok (2013) recorded higher rates of motivation, and, finally, Huang, Rauch, and Liaw (2010) found deeper learning and long-term retention of material experienced in VR. The positive results of studies using VR in education has not thus far resulted in specific recommendations for its adoption and implementation broadly in academic curriculum. As noted, most studies are limited to business and technology training simulations and medical fields. Research in other areas has yet to be thoroughly conducted (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020).

While research is limited, the studies that do discuss the increasing adoption of VR in postsecondary art history programs can be broken into five phases starting at the millennium. The phases of integration run parallel to other advancements in smartphones and gaming that use motion sensor technology and touchscreens. In 2001, the digitizing of cultural heritage sites (both existing and ancient) began, though the projects were primarily restricted to researchers in the field. 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.

Theories of Virtual Reality in Education

Most of the scholarship on immersive realities focuses on either the purely theoretical (Biocca & Levy, 1995; Brown, 2020) or technical (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020) aspects of their use. The first practical model for understanding the use of VR and its benefits in an educational context was Project

ScienceSpace in 1999. The project, which was developed by Salzman, Dede, Loftin and Chen, was geared towards creating immersive virtual environments for the instruction of scientific disciplines. The virtual learning model developed laid the foundation for future evaluation of the effectiveness of educational applications. The most insightful aspect of the team's approach was to consider not just the interaction between hardware, software, and user, which is critical for a basic understanding of the educational potential, but also how those subtly interact with other variables. These other considerations include what is to be learned or accomplished by the participant using the head-mounted display (HMD), learning styles of individual users, and the specific learning experience itself (Salzman et al, 1999).

Selecting, designing or developing a VR application or experience should not commence, the researchers argue, until the educational outcomes are first clearly defined to know what features are needed to reinforce them. The three features the technology enables include creating immersive 3-D environments, multisensory cues and multiple frames of reference. Additionally, the relative success of an integrated educational VR experience is dependent on certain characteristics of each individual learner, including age and gender, experience with technology, spatial ability, susceptibility to VR sickness, domain experience, and immersive tendencies. These characteristics have since been used in new categories for research in the field of user experience (UX) relating to VR. For instance, Kauhanen, Väätäjä, Turunen, Keskinen, Sirkkunen, Uskali, Lindqvist, Kelling, and Karhu (2017) elaborated on the characteristics to outline the categories that contributed to the success of an experience: Immersion, Presence, Disorientation, Sense of Control, Pleasantness, Exploration and Simulator Sickness. Given that every learner has unique experiences in the virtual learning environment, 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.

A more thorough study of the educational uses of VR was conducted by Radianti, Majchrzak, Fromm, and Wohlgenannt, (2020). The three areas the researchers focused on were the current domain structure in terms of the learning contents, the VR design elements, and the learning theories, as a foundation for successful VR-based learning. Literature distinguishes between behaviorism, cognitivism, and constructivism (Schunk, 2012). Other scholars also include experiential learning (Kolb & Kolb, 2012) to this list and, recently, connectivism has been introduced as a new learning paradigm (Dunaway, 2011; Siemens, 2014). However, these approaches have only marginally been considered with regard to VR in education. Literature confirms that most studies address only the sciences. In addition to the gaps described earlier, all six reviews considered only broad VR application domains in education (i.e., medicine or psychology) but did not shed light on specific types of learning content that can be taught using VR applications (e.g., declarative knowledge or procedural and practical knowledge).

Previous Application of Virtual Reality in the Art World

Immersive realities, such as VR, have clear application for the field of arts and culture. At the same time, the examples seen today with virtual museums and cultural heritage sites have a relatively short history. Starting around 2001, the digitizing of cultural heritage sites (both existing and ancient) began, though use and access

were primarily restricted to researchers in the field. Virtual environments were being developed using CAVE technology, such as that by the Foundation of the Hellenic World (FHW), a cultural heritage institution in Athens. Through the technology, a digital reconstruction of ancient cities began with Miletus, an Athenian and later a Roman colony on the coast of Asia Minor (Tzortzaki, 2001). The benefit for museums was immediately recognized. Roussou (2001), for instance, related that the technology would be ideal for museums to adopt to augment exhibitions in the physical museum space for "edutainment."

Several museums took up the charge between 2001 and 2010, including The Museum of Pure Form and The Virtual Museum of Sculpture. Unlike VR in the medical or scientific fields 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 a given area. 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.

At the same time, entire collections and museums were being digitized for viewing in immersive realities like AR and VR. Starting in 2006, the Center for the Art of East Asia in the Department of Art History, Division of Humanities, at the University of Chicago (CAEA) began developing the necessary technology to digitize, archive, and view collections of East Asian paintings and sculptures. These works include The Scroll Paintings Project and The Chinese Buddhist Caves Temple Projects, which seek to increase access to art-historical resources to foster collaboration and scholarship with works that are often inaccessible. 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 engagement duration, has led to the design of virtual learning environments (VLE) that are popular today.

In the last decade, the use of virtual learning environments as a means of delivering art historical content has become widely available through either digitizing real museums or creating computer-generated versions. 2011 witnessed the launch of Google's Arts & Culture, which allowed virtual visits to museums, accessible to anyone with a smartphone. With the addition of Google Cardboard in 2014, the head-mounted-display further democratizes the technology. Similar VLEs have been developed to tour real or virtual museums (VMs), such as the National Archeological Museum of Marche in Ancona, Gyeongju VR Museum, South Korea, and the Rijksmuseum, Amsterdam (Favro, 2006; Clini, Ruggieri, Angeloni, & Sassob, 2018). Most recently (2021), the Louvre digitized over 480,000 pieces from its collections and made them available on their online platform. Other experiences have been developed using game engines, such as Unreal Engine and Unity, to create a virtual museum for students to tour, as was developed to teach art history at the Universidad Nacional de San Agustin de Arequipa in Peru (Huaman, Aceituno, & Sharhorodska, 2019). Finally, in the last three years (2017-2020), full virtual tours of UNESCO World Heritage Sites have been developed.

The utilization of these virtual learning environments in higher education has received little attention. Ghida (2020) represents a rare example of immersive realities being used in postsecondary 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 relies 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 VLEs have been adopted predominantly in departments of architecture around the world, including at 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.

As noted, the mapping and digitizing of real-world works of art and monuments is ongoing, but there is also educational content being developed entirely digitally. The use of software and applications like game engines is increasing in popularity and has demonstrated usefulness for educational purposes. Several games have since been developed to assist in engagement, immersion and content retention with the gamification of art history. The virtual museum created for the Universidad Nacional de San Agustin de Arequipa in Peru 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 not only 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. Froschauer, Arends, Goldfarb, and Merkl (2011) created their online multiplayer Serious Game *ThIATRO* with similar intentions. With an understanding of the limitations of traditional methods for teaching art history in mind, creators of ThIATRO seek to provide the cultural-historical background through gamification to improve 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 encourages 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 by 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 traditional art history lectures, works of art are juxtaposed 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 et al., is that some comparisons can be made in a physical space, such as Canova's *Amor and Psyche* and the *Venus de Milo*, since they are both in the Louvre in Paris, while others like Michelangelo's *David* and *Moses* cannot as they are in different cities. Such examples illustrate the growing number of immersive reality labs on college campuses where original

educational content is being created for various disciplines.

The studies cited above provide a preliminary overview of the ways in which immersive reality has been used in postsecondary education to teach art history. A further distinction should be made here in that there are pre-developed applications and those that are developed on a bespoke basis by University faculty, staff, and/or students to test hypotheses or undergo experiential learning. The first is certainly the most prevalent and where those seeking to integrate immersive reality (XR, VR, MR, or AR) into curriculum should start (Christou, 2010). Such pre-developed applications are most used to present or reinforce topics presented in class and generally consist of a virtual environment where a student completes a specific learning activity or task.

The types of experiences afforded through applications for the teaching of art history are many and include Virtual Museums (VM), documentaries, open-world experiences, games, and exhibition design. Other applications have been developed 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 that allows the three-dimensional re-creations of ancient sites, buildings, and artifacts (Sanders, 2014). Taken together, there are many VR experiences to choose from when teaching any period of the history of art. Best practices for integrating these experiences will now be discussed.

Best Practices for Adoption

With technology developing at such a rapid pace and the rate of adoption increasing, educators must consider the best pedagogical practices within the limitations of the technology. Resnick and Morgan have outlined best practices for VR adoption across an institution of higher education (2017). Their three recommendations include: 1) implementing VR experiences that demonstrate new and innovative approaches to student satisfaction and success, 2) identify the disciplines where immersive VR environments can make the most impact and make coursework more engaging, compelling and effective for students, and 3) start with a "buy rather than build" strategy to ensure the low-impact adoption has the greatest chance for success at the outset.

Through the adoption of VR technologies, Resnick and Morgan claim institutions can set themselves apart and be more attractive to prospective students (2017). In order to put the adoption into practice, the team has four specific recommendations as carried out at the University of Toledo's Interprofessional Immersive Simulation Center. First, identify initial courses that can benefit from the technology and immersive 3D environments. The initial phase of adoption should be small to avoid costly mistakes before all data has been collected. Both educational and industry examples should be consulted and then adapted to fit best with a specific institution. The small, contained pilot should be led by partners across the institution in order to understand the full extent of support staff required to scale up. Have faculty and students experience different types and levels of VR from Google Cardboard to all-in-one HDMs in order to identify which platform and hardware is appropriate for different educational outcomes. Finally, share findings with the rest of the institution in order to establish best practices and lessons learned.

Discussion and Conclusion

The recommendations for integrating immersive reality in higher education provide a model for institutions to use. Starting with the "buy rather than build" strategy, institutions should begin with a low-impact approach by first identifying a pilot program. Outside of the sciences, art history offers an excellent first discipline to select given the highly visual nature of the content delivered and the availability of relevant pre-developed applications. In order to have success in the first pilot discipline, support and training needs to be made available for both students and faculty, including resources, examples, templates, rubrics, and sample assignments. At the outset, students should be allowed to use the most convenient headsets available to save on costs before wider adoption. Applications should be selected that are short in duration to acclimate students to the use of the technology. Flexibility needs to be built into assignments to improve student satisfaction. Students need to be offered several options, including non-VR alternatives for those with acute VR sickness. Finally, make the learning engaging to improve learning outcomes through teacher-to-student and student-to-student interaction.

The adoption of VR technology for the purposes of teaching Digital Humanities and art history is still in its infancy. The slow rate is attributable to two factors: prohibitively high startup cost for hardware and software and lack of training and support for faculty to integrate into coursework. However, recent advances in all-in-one headset technology, coupled with a lower-price point and more friendly user interfaces, has opened a path in 2021 to see the widescale adoption of the technology. The phases of integration run parallel to other advancements in smartphones and gaming that are used motion sensor technology and touchscreens. Starting in 2001, organizations began the process of digitizing cultural heritage sites, and making them available to researchers. Around the same time (2001-2010), we saw the gradual integration of limited VR experiences in exhibitions for edutainment purposes. The launch of full virtual museums coinciding with Google's Arts and Culture in 2011 has been continually expanding. The same year, several games were developed to assist in engagement, immersion and content retention with the gamification of art history. Finally, the last three years have seen the early attempts to map sites being realized with full virtual tours possible of UNESCO World Heritage Sites and complete museums being digitized.

Recommendations

Through a review of the literature, this study recommends the consideration of the following best practices for VR adoption in art history. In order to ensure a high level of engagement with students, the experience of using VR should be flipped and made student-centered. In order to accomplish the flipped model with VR, experiences should be social in order for students to interact with each other and the instructor. Start with existing applications and the "buy not build" approach to early adoption. One application or experience should not be used repeatedly for each class, but feedback solicited from students in order to keep the process of integration iterative to respond to what is soliciting the best outcomes for student learning. Finally, VR technology should be used to enhance learning and not replace existing content within a course.

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