

Comparing Virtual Reality Modalities and 360° Photography in a Construction Management Classroom

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The construction site field trip is a fundamental facet of the construction management curricula. The sights, sounds, smells, and feelings of being at a construction site have the capability of imparting a tremendous amount of valuable knowledge for students. Orchestrating these trips can be a burden on the faculty for a number of reasons – and often the typical course of action is not to do them. In this research study, an alternative approach was taken to mimic the experiential learning that happens in a construction site visit. This simulation involved the use of a sequential series of 360° panoramic photography (of an actual construction site) and two different form factors of virtual reality (VR). The researchers collected student perceptions of the experience, and comparisons of the two VR viewing options are analyzed and discussed in this paper. Overall, students' attitudes were favorable about the use of VR as a substitute for the construction site visit and the data indicate that they preferred more immersive form factors for viewing the 360° panoramic photography. Lastly, students offered, through open-ended feedback, some ways in which the experience could be made more authentic.

Key Words: Virtual Reality, Construction Education, Panoramic Photography, Experiential Learning, Field Trips

Introduction

Construction education is no longer limited to outdated textbooks, marker boards and passively lecturing instructors. That time in education is passed - with the accessibility of the Internet and the pervasiveness of mobile devices, students have nearly limitless access to information that empowers them to ask questions far more thought-provoking than before (Harris Poll, 2015, pp. 35-36). However, with these advancements in the classroom come different and unanticipated problems. Students have too many distractions, and often, there is too much data for them to sift through to come to any sensible conclusions about the questions that they have. Having students that are "media conscious" (Moskal, Lurie, & Cooper, 2004, p. 76) and fully expect that their learning experiences include the latest technology in the classroom presents a problem for faculty that are unable to diversify their pedagogy. The burden for managing these issues falls to faculty, and there needs to be an assortment of options available for them to satisfy the growing interests of technology-savvy students.

Many faculty recognize the value of successfully executed field trips where the students can observe ongoing construction activities, the management of those activities, and the sequential progress of projects over time (Eiris Pereira & Gheisari, 2017; Gunhan, 2015). Much like medical students gain academic experience by being with patients, construction management students gain academic experience by being on a construction site. However, there are some significant challenges present in managing a successful field trip. As (Eiris Pereira & Gheisari, 2017) noted in their research, some barriers included time conflicts with other classes, overly large classes to manage, and the safety of the students. These detractors make it difficult for faculty to incorporate field trips in their courses and often become excuses for not doing so. Research supports the importance of field trips for construction management students (Eiris Pereira & Gheisari, 2017; Gunhan, 2015) and construction companies are continually looking for graduating students that have *experience*. In light of this and the previously mentioned notion that today's students are "media conscious" (Moskal et al., 2004, p. 76) it is necessary to consider methods of educating them in ways that broaden their experience base while incorporating technology in the classroom that is familiar to the students.

Literature Review

Educators are continually looking for better ways to create experiential learning moments for their students despite the challenges in doing so (Tatum, 2010). Today's students are "media conscious" (Moskal et al., 2004, p. 76) and often insist upon the use of technology in the classroom. Students are no longer content with passive lectures (Kamardeen, 2015; Livingston, 2001) that are a repetition of facts and theories. Generation Z students (those born between 1995 and 2005) are disrupting the way that learning typically happens in higher education (Azhar, Kim, & Salman, 2018). These students are used to being continually connected to the Internet and are generally comfortable with using technology in the classroom (Chen, Seilhamer, Bennett, & Bauer, 2015). This zeal for technology is also apparent in the industry (JBKnowledge, 2017) as construction practitioners are adopting newer ways of gathering data, monitoring the work, and solving problems. An opportunity is available that seeks to couple the mindset of technology-savvy students to an industry that is in need of new practitioners capable of solving complex problems. Nevertheless, solely using technology will not combat the issues; students need access to industry experiences so they can draw connections between the theories they learn in class to the expectations of them as future practitioners in the industry. Educators view the field trip as an effective pedagogy for providing some level of experience for the students before they graduate (Gunhan, 2015; Pham et al., 2018; Sattineni & Williams, 2008). The field trip is an excellent educational activity because it allows the students to engage with industry practitioners. Furthermore, the field trip permits students to think about and question actual construction site activities while engaging many more senses than they could solely from the classroom environment (Wolf, 1980). However, many barriers must be overcome while orchestrating a successful field trip for students. (Eiris Pereira & Gheisari, 2017) elaborated on several barriers in their study on the subject, such as 1) safety, 2) time conflict with other classes, 3) class size too large to manage, 4) distance to an available site, and 5) limited support or resources.

Others too have recognized the importance of field trips for student learning, despite their challenges (Eiris Pereira & Gheisari, 2017; Meadati & Akhnoukh, 2018; Pham et al., 2018; Sunindijo, 2016). For instance, (Sattineni & Williams, 2008) revealed that construction is a complicated process that goes through many phases by which "the constructor must transform words and images into a functional three-dimensional entity" (Sattineni & Williams, 2008, p. 39). Furthermore, they concluded that the ability to translate the words, images, and symbols into three-dimensions improves through the constructor's experience. The absence of these experiences places a burden on the employer to train newcomers in the industry (Eiris Pereira & Gheisari, 2017). If academia is to prepare the graduating students in a manner consistent with industry expectations (American Council for Construction Education, 2017) there needs to be an element of experiential learning that educators could employ to address the issues above.

360° Photography and Virtual Reality

Educators need alternatives to the actual construction site visit that are also capable of providing the students with a sense of a similar experience. 360° panoramic photography dates back to the advent of plate photography (the mid-1800s - https://en.wikipedia.org/wiki/Panoramic_photography, accessed on September 26, 2018). Fortunately, the digital version of this technology has made the creation of 360° panoramic photography available to everyone with a modern day smartphone. The ease of using this technology and its availability is beneficial for content creators. The 360° panoramic photograph can be thought of as a spherical photograph that is representative of all that is visible from a single point in space. These photographs can be obtained in many ways, one of which includes a process of taking multiple photographs and digitally stitching them together to create a panorama. Another method is through the use of a camera that is specialized for taking a spherical image around a single point - the camera either has multiple lenses or rotates around a single point. These 360° panoramic images are being recognized as a useful teaching tool in the construction classroom (Pham et al., 2018), regardless of the way in which the spherical image is obtained. The modality by which the student views the 360° panoramic image also has several variations and is often characterized as virtual reality (VR). VR is thought of as a way of controlling visualization in three aspects: immersion, perception, and telepresence (Kim & Tom Leathem, 2018). *Immersion* is a measure of how "absorbed" someone is in the experience (Boas, 2013; Freina & Ott, 2015; Huang, Rauch, & Liaw, 2010) or conversely how readily the person can recognize that they are not in a fabricated environment. *Perception* is a measure of how "real" the fabricated environment seems to the viewer (Brenton, Gillies, Ballin, & David Chatting, 2005). And lastly, *telepresence* is a measure of how convinced someone is that they are no longer in the actual location of their physical selves (Akin et al., 1983; Seibert & Shafer, 2018). The research indicates that all modalities of VR contain immersion, perception, and telepresence (Boas, 2013), but at different magnitudes — not all modalities are equally convincing. Therefore, the modality used for the VR experience is important to consider when an instructor wants to replace, as accurately as

possible, an actual construction site visit. The modalities are too numerous to mention within the limits of this paper, therefore, a consolidated list of modalities has been illustrated in Figure 1 contrasting the effectiveness of creating a believable virtual experience.

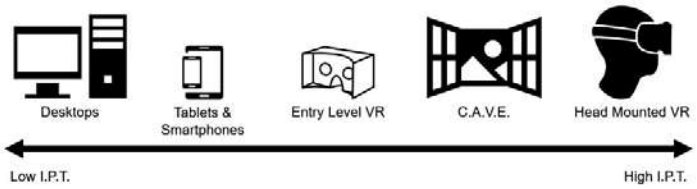

Figure 1: Comparison of immersion, presence, and telepresence (IPT) in various form factors with today's VR technology (Kim & Tom Leathem, 2018).

Research Motivation

This research is motivated on the basis that today's students are capable of taking part in a newer teaching protocol that simulates a construction site experience in a manner that is meaningful to the students. The combination of using 360° panoramic photography and a virtual reality display is being considered because it is capable of rendering a simulation that is life-like and can mimic the experiences that one gains through an actual construction site visit. In fact, other researcher have come to the same conclusions about this technology (Eiris Pereira & Gheisari, 2017; Kamat et al., 2011; Lucas, 2018; Messner & Yerrapathruni, 2003; Pham et al., 2018) and have studied the use of VR modalities in the construction management classroom. With this in mind, the adoption of VR as a pedagogical tool that will be viewed as a replacement for traditional construction site visits must be compelling enough in terms of its simplicity and ease of use. Aside from being a series of photographs that students view, there must also be some connection between the images that scaffold a learning experience (Golparvar-Fard, Peña-Mora, Arboleda, & Lee, 2009). Construction sequencing is also a concept that without practitioner experience is difficult to teach. Therefore, including a visualization modality that expresses the sequencing of construction activities is an essential component of a teaching experience that intends to mimics a construction site visit.

Research Aim

The aim of this research is to study student reactions and perceptions to the use of 360° panoramic photography as a supplement or replacement of an actual construction site visit when learning about construction sequencing. Additionally, the modality used for viewing the 360° panoramic photography will be compared.

Research Method

Students can obtain some learning benefit from observing photographs, and this research speculates that they can obtain more understanding if that medium includes panoramic and sequential 360° photography. This research study was conducted to ascertain student perceptions about two different virtual displays of 360° panoramic photographs. Furthermore, the 360° photographs were taken of a live construction project site over the course of four months.

360° Construction Photography

A 360° panoramic camera (Ricoh S®) on a tripod was used to capture digital photography for the study. A local project was the source of the sequenced construction photographs. The researcher was allowed to take daily sequenced photographs at a six pre-determined locations on the construction site. The progress photos were taken at each of the six sites every day for four months. All photographs were reviewed and shortlisted to a select six photographs that were used in the research study with the students. The photographs were selected because they best represented the progress of the construction of a foundation wall on the construction site.

Virtual Display Modalities

This research is focused on ways in which 360° photographs could be used to improve student learning and understanding of construction sequencing - because of this, two modalities for viewing 360° panoramic digital

photography were considered for this research study. The first modality included uploading the 360° panoramic photography to a cloud storage site so that it could be accessed on a handheld mobile device for viewing and interacting. Accessing a 360° panoramic digital photograph on a handheld mobile device allows the viewer to pan across an image and zoom in and out on details inside the image as if the viewer were positioned at the center of the 360° panoramic photograph. There is a certain level of limited immersion that is present to the viewer when looking at a 360° panoramic image in this manner. In addition to viewing the 360° panoramic photograph, the viewer can cycle through the sequential images to obtain a visual understanding of the sequence of the construction of a concrete foundation wall. The second modality consisted of a head-mounted virtual reality headset (Oculus Go®) on which the sequential 360° panoramic photographs were uploaded. The viewer would put on the VR headset and look at the panorama by rotating their head to obtain a different perspective of the setting that was captured in the 360° photograph. Here too the viewer could cycle through the sequential photographs to obtain a visual understanding of the sequence of the construction of a concrete foundation wall.

Student Demographics

The students that volunteered for this research included post-secondary construction management students taking a required construction technology class in the 2018 Summer Semester. The authors received survey responses from 52 students (n=52). Of the responses received, 48 (92%) identified as male and 4 (9%) identified as female. 13 (30%) students were between 19-20 years old, 34 (65%) were between 21-22 years old, and 5 (10%) were 23 years or older. 1 (2%) student was a sophomore, 42 (81%) were juniors, and 9 (17%) were seniors. No freshmen were involved in the study. 13 (25%) had no construction work experience, 13 (25%) had less than a year of construction experience, 16 (31%) had between 1-3 years of construction experience and 10 (19%) reported more than three years of construction experience. Lastly, 46 (88%) of the students indicated that they had no prior experience with virtual reality while 6 (12%) indicated that they have some experience with using virtual reality.

Setting and Student Participation

Following instruction about the necessity for the research study, students received a short presentation about the project included in the photographs. The researcher presented the two-dimensional construction plans for the concrete foundation wall and allowed the students to ask questions about the details. The students looked at an overall project site plan that contained annotations, locating each sequential 360° photograph on the project site. This was done to give the students some positional information about the photos that they were about to view. Following the presentation, students were invited to look at the 360° photographs in each of the two modalities; once on the mobile device and once on the head-mounted VR headsets. Students were allowed 15 minutes with each modality. Upon the completion of their experience, students were asked to respond to a short survey that would record their perceptions about their experience with the 360° panoramic sequenced photographs and the two different modalities by which the photographs were viewed.

Results

Quality of Simulation

One of the research aims was to create a simulated environment that could be considered a replacement or a supplement to the actual construction site visit. Students were asked to compare their experience in both modalities and rate how similar to the real environment they displayed (Figure 2).

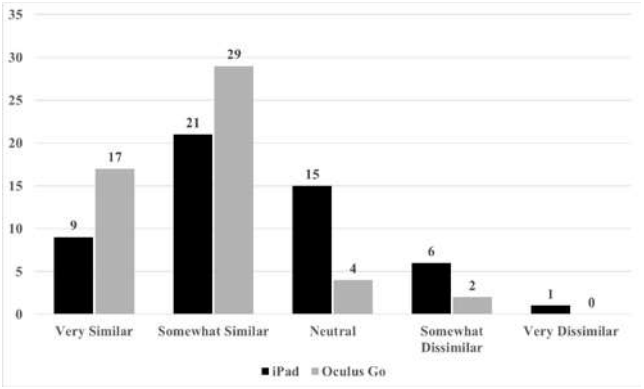

Figure 2: Student perceptions about the life-like quality of the simulation (*n*=52).

Students were asked to rate their perceived learning performance regarding the sequencing of the construction of a concrete foundation wall following the two different modalities. Figure 3 reports the student's perceptions of their understanding of construction sequencing.

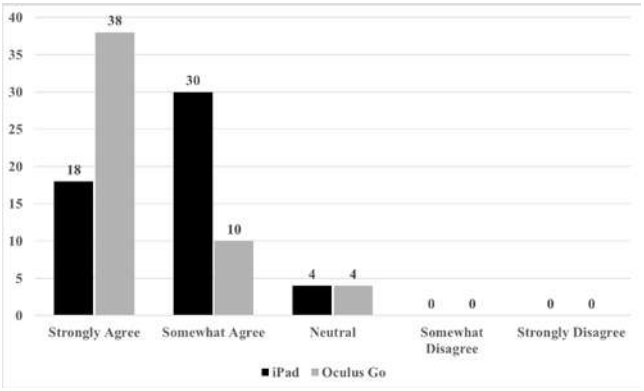

Figure 3: Student perceived learning performance of construction sequencing of a concrete foundation wall (*n*=52).

Modality Preference

This research study is also interested in the preferred modality for rendering the 360° panoramic photographs. Students were asked if the modality used could be a recommended supplement or replacement to an actual construction site visit. Figure 4 illustrates the comparison.

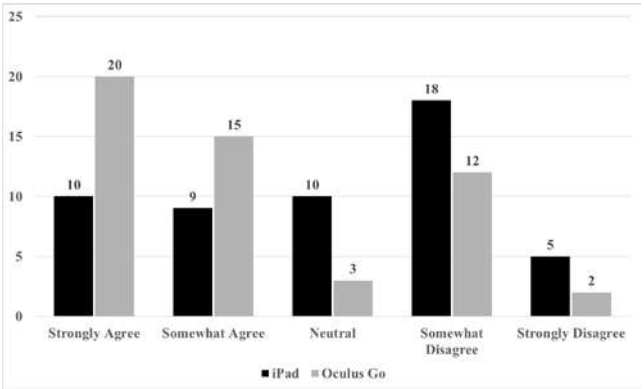

Figure 4: Student response to each modality as a replacement or supplement to an actual construction site visit (*n*=52).

Discussion

The scope of this research was to scaffold the learning experience for construction management students. Today's students are categorically Generation Z students and are media ready (Azhar et al., 2018) so, creating new pedagogies that meet this need would be prudent. While the use of photography in any classroom is not a new approach toward educating students, the use of 360° panoramic photography with the modalities mentioned in this research is relatively new. Furthermore, how 360° photographs are viewed have changed somewhat in recent years, and the wide-spread use of VR equipment is promoting the need to create better visual content. Therefore, this research study had a specific purpose of evaluating the use of the 360° panoramic digital content with more immersive and captivating modalities.

Immersion, Perception, and Telepresence

The researchers gathered student perceptions about the effectiveness of the experience, and as indicated in Figure 2, the quality of the simulations was examined by asking the students to report on their perceptions about the *reality* of the experience in both modalities. The question in Figure 2 also examines indirectly, the effectiveness of the immersion, perception, and telepresence of the virtual environment. The data indicate that both modalities felt life-like, as nearly 50% of the students indicated that the experience was *Very Similar* or *Somewhat Similar* in both modalities. More students indicated that the Oculus Go was more life-like than the same experience on the iPad®, signifying that in terms of reality and life-like experience, the VR headset form factor is a more authentic experience. Therefore, while using 360° panoramic photography is important in trying to replace or supplement the actual construction site visit, it is important to consider the modality that is used to create the simulated environment.

Examining Perception

Immersion, perception, and telepresence are important to consider in the simulated experience. However, focusing on viewer perception must be justified because the modality is being used as a replacement for the active learning that happens within an actual construction site visit. Since perception addresses the reality of the viewer's experience, it is presumed that the perception would be an important factor in the successful recreation of the life-like experience. Therefore, the researchers measured the student's perceptions in terms of an ability to interact with the simulated environment. The data indicate that most students experienced an elevated level of interaction with the simulated environment. The amount of interaction was higher with the Oculus Go as compared to the iPad. This data along with the data in the previous subsection concerning immersion, perception, and telepresence creates a simulated experience that is perceived realistic to the students. This *realism* is an important consideration when the intent is to replace or supplement the actual construction site visit.

Examining Telepresence

Telepresence is a measure of how disconnected from place and/or time a viewer perceives a virtual experience. The researcher measures the effectiveness of the change in time by sequencing the 360° panoramic photographs in such a way as to allow the students to view the progress of a foundation wall over four months. Regarding location, each modality was used to mimic an environment that virtually placed the students on the construction site. Regarding time, each modality allowed the students to alter their view so they could progress through time and observe the sequential construction of a foundation wall. The data indicate that the students perceived some effects of telepresence. With both modalities, students predominately responded as *Strongly Agree* to *Somewhat Agree* that the simulation helped them to understand construction sequencing and supported the reasoning that the simulation let them experience a temporal change from their current time.

A Replacement for Construction Site Visits

Concluding the student's perceptions, they were asked their opinion about both modalities and whether the modality could replace or supplement a live construction site visit. Responses for the iPad were somewhat evenly distributed except for a larger portion (34%) indicating that they *Somewhat Disagreed* that the iPad was a good replacement for an actual construction site visit. On the other hand, with the Oculus Go, while there was a significant number that indicated that they *Somewhat Disagreed* to *Disagreed* (27%), more perceived that the Oculus Go could replace or supplement an actual construction site visit (67% combining *Strongly Agree* and *Somewhat Agree*).

Conclusion

It should not be implied categorically that this research is suggesting a full replacement of the construction site visit. However, in light of the current literature, there is a need to have similar alternatives when the current alternative is not to do them. The benefit from experiential learning on field trips has been researched, and there is no good reason not to do them. The limited scope of this research study allowed the researchers to gather some important student perceptions which should allow for a more thorough and detailed study in the future that explores the significance of the student's learning experience. Where this research differs was in creating a modality that increased the realism of the experience through a focus on immersion, perception, and telepresence innate to the form factor being used to view the 360° panoramic photographs. With this in mind, there were some limitations that should be considered in future iterations of a similar study. There was an opportunity for the students to report open-ended feedback to the researchers that were informative about how to improve the experience. Some suggestions included, 1) adding a visual schedule, 2) adding sound, 3) the ability to move freely within the panorama, 4) clearer pictures – a quality issue, and (5) including video.

Another area of concern that was not elaborated in this paper and is commonly inherent in the use of VR technology is motion sickness. Students were intentionally allowed only 15 minutes use of the head-mounted VR form factor, knowing that prolonged use could adversely affect the students in the research study. In future attempts of this research, this effect will need more consideration, as it may prohibit students from completing the experience.

Lastly, the researchers thoughtfully considered simplifying the setup for the research study as much as possible, knowing that a complicated technical setup would provide a reason for educators to dismiss the use of the pedagogy. The setup for each modality included a single piece of hardware for gathering images and a single piece of hardware for viewing images. No ancillary equipment or programming was necessary to furnish the experience for the students. In keeping to these principles within this research study, the recommendation could be more widely accepted in the construction management classroom.

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