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A Pilot of Student Guided Virtual Reality Tours

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Abstract. Construction management programs that contain technology courses, often teach students how to create building information models (BIM). The problem is that creating these models for the first few times is a difficult process. This learning process pushes students' spatial abilities to the limit as they try to understand how buildings come together while trying to perfect their final product. However, when students can view their models at a 1:1 scale instead of on a flat computer screen, they start seeing things differently. Recently, nearly 60 students took part in completing their regularly assigned BIM project in a construction technology class. With the aid of an OculusGo® virtual reality headset, students walked in their finished product and were able to critique their work from a different perspective. Furthermore, this pilot placed the student's in their model along with their classmates. This way, the author of the model could take their classmates on a virtual tour of their work, allowing multiple people to review and critique the finished product. This paper describes a pilot inquiry into the use of collaborative virtual reality in a four-year construction management classroom to improve student's building information modeling skills. This paper presents the students' feedback about the experience and documents the researcher's observations in preparation for a plenary study on collaborative virtual reality in the classroom.

Keywords: Virtual Reality, Construction Education, Active Learning, Collaborative Learning, Spatial Skills.

1 Introduction

This pilot inquiry was modeled as an action research study [1] and is being conducted to aid in the final design of a larger study on collaborative virtual reality (VR). In the context of this pilot inquiry, a series of assignments were used to comparatively evaluate the impact of using collaborative VR in the classroom. In particular, the VR was used to help the students score their classmate's assignments. The presumption from using VR in this manner is that the students would enhance their parametric modeling skills more than through the use of traditional scoring techniques. A limited amount of performance data was collected along with student perceptions of the new critiquing exercise. This pilot inquiry intends to establish a methodology that could be used to gather more detailed and statistical data in the use of this novel approach toward critiquing. Lastly, the instructor was motivated to introduce students to collaborative VR while in academia because it could prepare them for its use in industry [2].

2 Past Research

This pilot inquiry seeks to determine if an alternative method of critiquing students' parametric models provides the students with better feedback than through conventional methods of critiquing. Collaborative critiquing was selected as the alternative method for the classroom because of its similarity to the design industry practice of collaborative design. Collaborative design is used across many disciplines; however, in the building industry, it generally involves an iterative process where feedback is continually used to affect the final product [3]. Student peer assessment or peer critiquing uses multiple feedback channels so that students can obtain a wide variety of suggestions to improve their learning [4]. Both processes are similar in that feedback is encouraged and can be used to improve the final outcome. This pilot inquiry was set up to mimic the design process because the industry is starting to make use of VR to enhance that process. Therefore, using VR supported collaborative peer critiquing should improve the students' skills.

In the United States, construction management programs teach students how to interpret two-dimensional (2D) construction plans [5]. That interpretation involves the student reading lines on the construction plan and creating an abstract spatial image in their mind [6]. Often it is necessary to reverse that order, and the student must be able to observe a three-dimensional (3D) rendering of a building and interpret its 2D representation. These back and forth translations are what faculty train in the construction management class. Unfortunately, many students, for various reasons, struggle with this spatial translation skill [7]. The process of creating parametric models requires more advanced spatial skills from students [8], and spatial skills can be improved [7]. Unfortunately, due to the pace of learning within most construction management programs, students rarely have sufficient time to practice their newly acquired skills in plan reading, and subsequently, they have difficulties in properly creating parametric models. It would be beneficial to have more effective pedagogies available to students when it is clear that they continue to struggle.

Learning is achieved if students are not overloaded during their educational experience [9]. There are many ways by which they can become overloaded or distracted during their learning experience and these amount to cognitive load. Cognitive load can be so overwhelming that it prohibits the student from properly storing newly acquired learning in their working memory [9]. Technology is an infamous distraction (high cognitive load) to the modern classroom but, if the technology is applied properly, it can add positive value to the learning experience [10, 11]. Therefore, considering the introduction of technology is necessary when a new pedagogy is introduced [9]. However, in a classroom that is focused on teaching BIM, the need to introduce technology is expected.

The industry is moving toward increased use of BIM because of its many benefits [12] so students that want to be future practitioner must be proficient in its use. Focusing on pedagogy that addresses this need is imperative, and through the use of properly applied collaborative technology, students will obtain enhanced feedback that improves their learning all while experiencing technology that the industry supports.

3 The Pilot

This section describes the process taken to obtain pilot data that would be used to develop a methodology and hypothesis for a future plenary study on collaborative VR. This pilot inquiry took place in the summer semester of 2018 with postsecondary students that were required to take a construction technology course. In this course, the students learn how to use 3D modeling software (Autodesk Revit® and Trimble SketchUp®). The instructor collected performance and perception data, while students completed a series of classroom assignments. The assignment selection involved modeling a 3D site logistics plan for a commercial building project.

3.1 Method 1: Modeling and Traditional Critique

The first assignment that was monitored involved the students creating a 3D site logistics model of a commercial building project. Once the students completed the assignment, they were asked to present the model to the class for traditional (anonymous) peer critiquing. All presentations required the students to display their model to the classroom on an overhead projector using the features of the modeling software to guide their classmates through their work. The workflow for this method is illustrated in Figure 1.

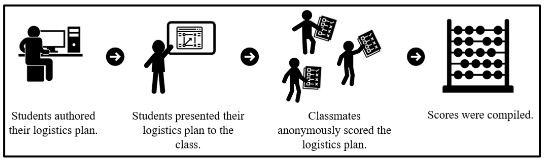

Figure 1. Method 1: Workflow with Traditional Critique

3.2 Method 2: Modeling and Collaborative VR Critique

Later in the semester, with the same students, another similar assignment was completed. However, the students were asked to present their model by curating a tour through the model using a VR headset that would be worn by all students. The assignment's author was given the role of tour guide, and all other students were considered tourist. Viewing the model in this manner was different for the students in that everything visible to them was at 1:1 scale as if they were in the model itself. The workflow for this method is available in Figure 2, and an illustration of the students participating in a VR guided tour is available in Figure 3. The collaborative nature of this configuration allowed all students using the VR headset to see each other in the model as avatars (floating headsets). Upon completing the tour of the model, all students completed a peer (anonymous) critique scorecard and a perception survey.

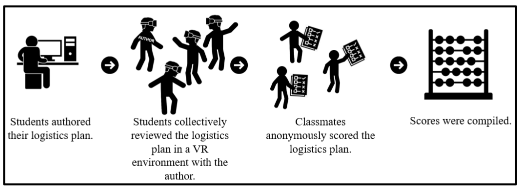

Figure 2. Method 2: Workflow with VR Critique

Figure 3. Students Presenting Their Assignment using Virtual Reality

3.3 Scorecards and Perception Surveys

The anonymous assessment for the models was handled through a grading rubric designed by the instructor. Each student scored the models that they viewed in Method 1 (see Figure 1) and scored again in Method 2 (see Figure 2). The following three criteria were used in both methods.

1. Rate the quality of the logistics model.
2. Rate the effectiveness of using the model as a tool for communicating site logistics.
3. What is the overall ranking for quality that you would give to this student's work?

Lastly, the students also responded to a perception survey of their experience in the VR tour.

3.4 Virtual Reality Setup

The virtual reality setup consisted of two components. The cloud storage site for the student's parametric models (InsiteVR® accessed via https://app.insitevr.com/) and the VR headset (OculusGo®).

4 Results

4.1 Demographics

The students that participated in this pilot inquiry were selected because they were representative of students in a common four-year postsecondary construction management program in the United States. A review of data from the American Council for Construction Education [5] indicates that the demographics for these students are similar to those found across the United States. Additionally, since the four-year program includes opportunities for students to obtain work experience in the way of internships and cooperative education programs, it is not surprising that most indicated that they had some experience in the construction industry. Lastly, the students were asked if they had used VR before, and most had indicated that they had some exposure to it in the classroom. Both of these demographic indicators were documented because they may have an impact on the results presented in this paper and should be evaluated further in an expanded research study.

The students that participated in this pilot did so as a tourist (students that were guided through a model by another student) or a tour guide (a student responsible for leading other students through their model). The following table summarizes the demographics of each of the groups of students:

Table 1. Student Demographics

Characteristics	Tourists (*n*=64)	Tour Guides (*n*=17)
Experience Working in the Construction Industry		
Yes	44 (68.8%)	9 (52.9%)
No	20 (31.3%)	8 (47.1%)
Have You Used VR in the Classroom Before?		
Yes	44 (68.8%)	11 (64.7%)
No	20 (31.3%)	6 (35.3%)

4.2 Comparison of Critiquing Methods

There were two methods for critiquing that the students engaged in during this pilot inquiry. The first method consisted of a traditional critique of a classmate's model by using a projector display that the authoring student would use to present their work to their classmates. The second method consisted of a VR based approach whereby the students critiqued their classmate's work in a collaborative VR environment. Following the student's presentation, their classmates provided anonymous feedback (critique) for three criteria.

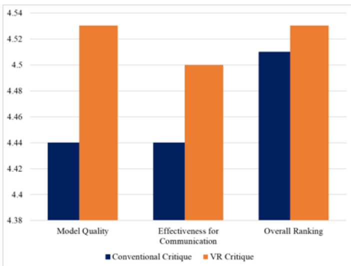

Figure 4. Comparison of Critiquing Methods

4.3 Comparing Responses Between Tourists and Tour Guides in the VR Critiquing Method

The students, regardless of their role as *tourist* or *tour guide*, completed a perception survey. Figure 5 illustrates the differences in perception to nine criteria that were asked following a tour of a student's models. The nine criteria are as follows:

Q1: Rate the quality of the logistics model.

Q2: Rate the effectiveness of using the model as a tool for communicating site logistics.

Q3: What is the overall ranking for quality that you would give to this site logistics plan?
Q4: Upon completing this critiquing exercise, do you think your modeling skills have been enhanced?
Q5: Upon completing this critiquing exercise, do you think your construction management skills have been enhanced?
Q6: Rate the tourists or the tour guide.
Q7: Did the model represent the proper scale between all the elements in the model?
Q8: Did the model make the best used of colors and textures?
Q9: Did the VR technology interfere with the learning experience during your critiquing?

Figure 5. Comparison between Tourist and Tour Guides in the VR Critique

5 Dicussion

5.1 Comparison of the Critiquing Methods

As apparent in Figure 4, the perception from the students when critiquing site logistics models between a conventional critique and a collaborative VR critique shows consistently higher scores overall for the VR approach. However, the scores are not significantly much higher (0.09 points difference at the greatest) which may indicate that the two approaches result in balanced scoring for the logistics models, regardless of the method of reviewing them. Moreover, since neither of the critiquing methods resulted in significantly different scoring results, the introduction of the collaborative VR technology does not appear to cognitvely overload students and impede their learning. Otherwise, we may expect to see collaborative VR critique scores in Figure 4 lower than the conventional method of critique. Therefore, expanding this pilot to the plenary research study should seek to hypothesize that the critiquing method does not affect the student's cognitive ability to learn.

5.2 Comparing Responses Between Tourists and Tour Guides During VR Critique

This part of the pilot inquiry was staged to determine if there was a difference in the learning experience between the two roles in this critiquing method. In Figure 5, the responses to questions Q1, Q2, Q3, Q4, Q5, Q6, Q7, and Q9 were similar with only an average difference of |0.2|. This data indicates that there was not much difference when one acted in the role of *tourist* or acted in the role of *tour guide*. However, Q8 requested that the students respond to the author's use of color and texture in their model. The difference was |0.7| with the *tour guide* indicating a more critical review of their model than the *tourists*. Again, not a significant difference between the roles and indicates that the critiquing was not unfairly biased. There is balance in the assessment regardless of the role that the student takes as well as an apparent balance in the learning experience as reported from the student's responses to questions Q4 and Q5. Much like the result from the comparison of the critiquing methods, there is a balance between the perceptions of the different roles. What this should allow for in the plenary study is an unbiased analysis of analytical scores in a pre and post assessment data gathering experiment.

5.3 Future Work

As an aside, the individual score for Q8 and Q9 were about |0.5| lower than the individual scores for Q1, Q2, Q3, Q4, Q5, Q6, and Q7. The students were less confident that these two questions contributed positively to their experience in the VR critiquing method. The data indicate that students can be more critical of the model in a way that was not available to them when critiquing them traditionally. This fact is supported regardless of whether they participated as a *tourist* or a *tour guide*. It is obvious that viewing the model in a 1:1 scaled immersive environment is different than viewing them on a flat 2D display. There is a possibility that critiquing using this method would allow the students to be more critical and in turn, learn more from the experience. More analytical research would be needed to support this notion.

Lastly, this pilot inquiry did not conduct a formal or analytical review of the student's pre and post scores. While it did appear that the students learned from the VR experience; their future models included more details, better coloring, and more informative annotations. Data collected in this pilot inquiry did not allow for isolation of all the variables; therefore, obtaining a truly accurate dataset that could speak to the student's learning performance was not a part of this pilot inquiry.

6 Conclusion

While the results are not based on a systematic pre and post test experimentation, this pilot inquiry provides a basis for developing the methodology and establishing hypotheses that could be used in an expanded research, resulting in more actionable and generalizable results. Concluding this pilot inquiry, the following points were determined:

1. **Impact on Critiquing** - Regardless of how a faculty allows the students to self-critique parametric models, the scores are unaffected. The data from this pilot inquiry did not appear

to show significant bias for critiquing the models using a traditional approach (as detailed in section 3.1) over using a collaborative VR approach (as detailed in section 3.2).

2. **Roles in the VR Approach** - The VR approach requires at least one students to take on a different role than the remaining students, and this role did not appear to bias the scoring of the student that authored the model. The learning experience between the two roles shows to be balanced.
3. **Cognitive Load** - The introduction of the VR technology did not appear to be a distraction, and the data indicated no additional cognitive load, allowing for a balanced learning experience regardless of the method used to critique. However, a more analytical verification of this fact should be pursued in an expanded research study.

The results of this pilot inquiry found that using collaborative VR critique was not measurably better than using a traditional method of critique. However, qualitative data from the students suggested that they received better feedback on their work when collaborative VR was used. Consequently, the results from this pilot should encourage more detailed and analytical research in the use of collaborative VR for educational use in the construction management classroom.

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