**Where’s the Germs? The effects of using virtual reality on nursing students’ hospital infection prevention during the COVID-19 pandemic**

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VR COVID-19

**What is already known about this topic**

- Virtual reality has been widely applied in nursing education with positive impact.
- Nursing students perceived the virtual reality inquiry-based learning activity useful to substitute for in-hospital training.

**What this paper adds**

- Virtual reality inquiry learning activities can help promote nursing performance in both the traditional classroom and online settings.
- Students can have similar academic performance between the classroom and online modes despite having different experiences with the two modes.

**Implications of study findings for practitioners**

- Virtual reality integration might be implemented by pre-training to make sure students are comfortable with the technology before jumping into course activities.
- The instructional design and delivery of a virtual reality learning activity greatly influenced the students’ learning experiences, rather than the use of virtual reality technology itself.
Introduction

In the wake of the COVID-19 pandemic online education has become the new normal. But for nursing students, augmenting online education to include the virtual reality (VR) of being at the bedside, becomes an essential training ground. Unfortunately, many hospitals restricted student access to patients during the COVID-19 pandemic. Many student nurses in training were deemed non-essential healthcare workers and clinical rotations were cancelled (Dewart, Corcoran, Thirsk, & Petrovic, 2020). Without time in the hospital setting, nursing students were faced with a disadvantage. How to educate a future nursing workforce outside of the traditional settings is a challenge for nursing education.

The purpose of this study was to examine the impact of shifting a virtual reality activity from a traditional classroom to the online learning environment during the COVID-19 pandemic. The goal of this study was to look at best practices when utilizing a VR activity with nursing students. The ultimate outcome was to design a meaningful and sustainable virtual learning experience which could be easily adapted during and after the COVID-19 pandemic.

Literature Review

VR has been widely applied in higher education with positive impact (Howard, Serpanchy & Lewin, 2018). VR technology affords realistic immersive experiences to enable learners’ presence, active learning, and engagement when real experiences are not accessible. Kyaw et al. (2019) conducted a systematic review of VR in medical education and found that medical professionals performed better in cognitive related skills in VR (e.g., computer 3D model and virtual world) compared to traditional learning environments. In fact, compared to traditional classroom and computer-based simulated practice, virtual reality was more effective in developing clinical psychomotor skills for pre-licensure student nurses (Rourke, 2020). When compared to the traditional training with regular video approach, nursing students showed higher learning motivation and satisfaction after taking a 360-degree video training of childbirth education (Chang
Furthermore, Valenti, Lund, and Wang (2020) found positive outcomes when the new students received a VR student orientation instead of traditional text-and-links content. The new students’ anxiety level greatly decreased after virtually meeting and interacting with the faculty. Howard and Gutworth (2020) found that VR training programs were more effective in social skills development compared to other traditional training programs. During COVID-19 pandemic, nursing students perceived the simulated clinical scenarios useful to replace in-hospital training (De Ponti et al., 2020).

Most of the VR studies have been conducted to evaluate the effectiveness, affordances, and challenges of the technology integration in educational settings (Garzón, Pavón & Baldiris, 2019). But very few studies have investigated the new instructional design principles on how to enhance learning in VR, especially how to apply the VR technology in actual teaching and learning (Mayer, 2019; Parong & Mayer, 2018). Similarly, Radianti et al. (2020) conducted a systematic review of VR integration in higher education and found that VR applications were developed as experimental work rather than being applied regularly in actual teaching. There is a pressing need to understand critical instructional design and traditional classroom implementation issues, such as how to create inclusive VR simulation learning content (Pate, 2020), how to prepare students for successful VR learning (Petersen, Klingenberg, Mayer, & Makransky, 2020), and how to effectively scaffold students when students are engaged in the AR/VR activities (Ibáñez & Delgado-Kloos, 2018).

When it comes to online learning, VR starts to show great potential in student engagement. Researchers have used VR to mirror remote students as avatars into a classroom in order to encourage remote students’ participation and engagement with instructors and peers (Pietroszek & Lin, 2019). Educators have explored the potential of using the online social VR environment to encourage learners to interact with peers and active learning (Liaw, 2019). Though innovative VR approaches have been explored in creating engaging online learning experiences, little research has
VR COVID-19 systematically examined the effectiveness of VR technology in actual online classes and less is known about the differences of VR learning between online and classroom classes.

**Inquiry-based learning**

Inquiry-based learning encourages students to construct knowledge through actively exploring, discussing, and solving real-world problems (Bruner, 1961). Compared with traditional instruction, an inquiry-based learning approach fosters the learners’ critical thinking skills, problem-solving, clinical reasoning and capability to think like a nurse (Theobald & Ramsbotham, 2019). Instead of offering direct instruction, the instructor serves as a facilitator to guide students’ own learning inquiry. The inquiry-based learning approach has great potential in healthcare education and should be integrated into more classes (Kirubaraj & Santha, 2018).

VR affords the inquiry-based learning possibilities where learners actively engage with content and peers to conduct their own inquiry research beyond their traditional learning context. VR applications (e.g., Google Expedition®) afford first-person perspective and in-situ contextual information with 360-degree navigation and 3D view. By connecting research in VR with real-world situations, students could creatively tackle real-world problems and develop critical thinking and problem-solving skills (Minocha, Tudor & Tilling, 2017). For example, Netland, Flaeschner, Maghazei, and Brown (2020) used a manufacturing factory virtual tour to offer students a guided discovery learning experience in a graduate operations management course. Students collected production site information, analyzed the site layout, and offered production improvement plans based on their VR discovery experience. In an educational technology course, Neumann (2019) adopted place-based pedagogy to encourage preservice teachers to experience and create virtual tours for digital literacy practices, which could be easily integrated by teachers. This research aimed to fill the gap in the literature by exploring the students’ performance and perceptions of an inquiry-based VR learning activity while online during the COVID-19 pandemic.

**Methods**
The study design was a descriptive, quasi-experimental pre- and post-test model. A convenience sample of undergraduate nursing students enrolled in a west coast public university were asked to participate. Participants were junior level nursing students during their first medical-surgical hospital rotations. The first sample of nursing students experienced the VR activity while in the classroom (n = 25). The second sample of nursing students experienced the VR activity while online (n = 25) during the COVID-19 pandemic. These students were excused from clinical training in the hospital within the first few weeks of the semester. In addition, all courses moved to a mandatory online format during this time. The investigation was approved by the university’s Institutional Review Board Committee on Human Research.

The VR activity was conducted on a web-based platform called Google Tour Creator® which allows instructors and students to easily create and share their own virtual tour from computer. Built upon the Google Street View panoramas or the users’ own 360-degree photos, the virtual tour allows users to add informational point of interest with narration, image, or text into the scenes. The virtual tours can be published and shared through Poly (poly.google.com) an online repository for 3D content. Viewers can view the tour through a web browser or in VR using a viewer like Google Cardboard®.

**Measurement** included an investigator developed online questionnaire preceded by informed consent. Students who preferred not to participate were able to defer answering questions without consequences. The questionnaire measured demographic variables, number of infectious hospital sites that were correctly identified and evaluation of a web-based tour creator platform using three Likert-scale questions scored from 1 = strongly disagree to 5 = strongly agree. In addition, open-ended comments were collected.

In this study, the VR learning activity consisted of seven steps conducted over 90-minutes (see Table 1). First, students were introduced to the VR tour creator platform (15-minutes) where they watched the instructor access, explore and label sites in a hospital room. Second, students
VR COVID-19 took a pre-test questionnaire to assess their own knowledge of the most infectious sites in a typical hospital room (10-minutes). Third, students were assigned to class groups or breakout rooms of 3 or 4 individuals and given an evidence-based practice article to review. Students were asked to write an American Psychological Association (APA) style annotated bibliography concerning various locations for hospital acquired infections (20-minutes). Fourth, students were then asked to create a tour from a 360-degree picture provided. Fifth, students were asked to label the most infectious areas using the points of interest feature on the virtual reality tour (15-minutes) using an APA citation. Sixth, students were asked to discuss nursing interventions for sanitization of various areas discussed in the articles (20-minutes). Finally, students took a post-test questionnaire to re-identify infectious sites after reviewing articles. In addition, the post-test assessed performance and perceptions of a VR inquiry-based learning activity (10-minutes).

The same instructor delivered both the classroom and online instruction. For the VR learning activity, the main differences for instruction was the delivery format. Course materials were delivered through an online learning management system. In the traditional classroom setting, students in groups could sit next to each other, observe neighbors’ screens and interact while using their laptops. In contrast, the online course was delivered during the COVID-19 pandemic period. The live session was hosted synchronously on Zoom®, a web conference platform. Students were split into groups and sent to work in breakout rooms. The instructor visited each breakout room to check on the students’ progress and answer questions. One disadvantage is only one student was able to screen share at a time. Other students could view and discuss with audio or text chat only.

**Statistical Analysis**

Questionnaires were analyzed by quantitative methods. For demographic data, results were calculated by frequencies and descriptive statistics. For performance based on knowledge assessment, frequencies and means were conducted on student identification of correct infectious
VR COVID-19 sites on pre-test and post-test questionnaire. For perceptions towards Google Tour Creator®, independent-samples t-tests were conducted to compare differences between traditional classroom and online groups.

**Results**

Two sessions were conducted using undergraduate nursing students ($N = 50$). The first session was held in Spring 2019 in a traditional classroom ($n = 25$). An online session was held in Spring 2020 on a communication platform ($n = 25$) during the COVID-19 pandemic. There was no significant difference between the traditional classroom and online groups in terms of demographic information. Each group ($n = 25$) was similar in age ($M = 23$ years; $SD = 3$ years), gender (female nursing students 74%, male nursing students 24%, non-binary 2%) and ethnic background (Asian 48%, Caucasian 28%, Pacific Islander 10%, Hispanic 12%, Indian 2%).

**Performance**

Students were asked to identify infectious sites based on their own knowledge. After being provided with a flatten panorama image of a typical hospital room, students were able to identify four ($M = 4.28$) correct sites. Although there were some sites selected by students that did not harbor pathogens (such as the countertop). After reading evidence-based practice articles in small groups of four or five, students were able to correctly identify ten infectious sites ($M = 10$) in a typical hospital room. Both groups demonstrated similar improvements in labeling sites after the VR learning activities. There was no significant difference with sites identified between the group of students in the classroom versus the group of students online, even after the onset of COVID-19.

**Perceptions**

Students agreed that Google Tour Creator® was easy to use ($N = 50$). However, findings demonstrated there was a significant difference in the scores between students who were given classroom instruction ($M = 4.3$, $SD = .90$) and students who were given online instruction ($M =$...
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3.5, \( SD = .77 \) about the use Google Tour Creator\(^\circledR \); \( t(48) = 3.37, p = .001 \). Students agreed that using Google Tour Creator\(^\circledR \) was a good learning tool (\( N = 50 \)). Findings demonstrated there was not a significant difference in the scores between students who were given classroom instruction (\( M = 4.3, SD = .90 \)) and students who were given online instruction (\( M = 4.1, SD = .9 \)) that Google Tour Creator\(^\circledR \) was a good learning tool; \( t(48) = .47, p = .64 \). Finally, students agreed that labeling infectious sites in VR could help them in a hospital setting (\( N = 50 \)). Findings demonstrated there was not a significant difference in the scores between students who were given classroom instruction (\( M = 4.3, SD = .90 \)) and students who were given online instruction (\( M = 4.2, SD = .90 \)) when trying to use Google Tour Creator\(^\circledR \); \( t(48) = .46, p = .63 \).

Nursing students also provided written comments about the activity. One student stated, “I totally enjoyed working with the tour creator. It was like a find it game for nurses. Instead of “Where’s Waldo?” it was like “Where’s the Germs?” Many of the areas I thought would be dirty were in fact, clean and equipment that was dry and plastic were in fact, really dirty.” Another student mentioned they appreciated using evidenced-based practice articles, “It was great to get information about different areas around the patient and nurse that would be potentially infectious from the research provided. I don’t think I will ever forget the main places in a room that harbor disease.” Finally, one student commented that the activity helped them recognize high-risk areas, “I am so glad I learned which spots to look out for! I can’t believe when I was in the hospital, I would rest my hand on the bed rail when I was talking with the patient! It totally inspires me to wash, wash, wash and clean, clean, clean.”

**Discussion**

First, findings suggest that the VR inquiry learning activities can help promote nursing performance in both the traditional classroom and online settings. Results indicated that both groups of students identified a correct number of infectious sites at the end of the VR inquiry learning activity. The findings are consistent with previous comparison studies that classroom and
VR COVID-19 online learning are similarly effective in developing nursing students’ clinical skill (McCutcheon, Lohan, Traynor & Martin, 2015). Students can have similar academic performance between the classroom and online modes despite the students might have different experience satisfaction and challenges in the two modes (Braun, 2017).

Second, perceptions differed between how easy it was to use the tour creator. There was a significant difference in the scores between students who were given classroom instruction versus students who were given online instruction. It may have been that the demonstration of the tour creator platform in the classroom was more robust than what was received online. Previous studies found that 360-degree virtual tour or 360 videos can help students get virtual experiences and orientations that are hard to access otherwise (Chang et al., 2019; Valenti, Lund & Wang, 2020). But the students usually take the passive role as viewers which does not fully support students’ deeper learning. In fact, in an online setting it may be more difficult to ask questions in front of a large group or ask the instructor to repeat the demonstration. In addition, another possible reason is that online students had more challenges to work together in the online Zoom breakout room.

Findings implicated that the online students had more challenges in working effectively in an online group rather than the Zoom conferencing technology itself. The challenge found in the present study echoes previous studies. For instance, de Oliveira Dias, Lopes and Teles (2020) reported that Zoom breakout room itself was not effective in supporting students’ online group work so additional technology (e.g., WhatsApp) or scaffolding should be adopted to assist. Cirillo, LaRochelle, Arbaugh and Bieda (2020) argued that in order to use Zoom effectively in teaching and learning, both instructor and students need to understand the difference between classroom and online communication and collaboration. Furthermore, the findings of the present study indicated the students’ lack of readiness with the Google Tour Creator® tool directly impacted the students’ collaborative learning experiences, which might explain the online students’ perceptions of viewing Google Tour Creator® as not an easy learning tool.
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The findings of online students’ struggle with Google Tour Creator® indicated the importance of preparation activity before students’ collaborative inquiry-learning activities. An introductory activity or pre-training might help students feel more comfortable and confident in using the tool. This finding resonates with literature on VR integrated learning. For example, students perform better in a transfer test when they participated in a pre-training before immersive virtual reality field trip (Petersen, Klingenberg, Mayer & Makransky, 2020; Meyer, Omadahl & Makransky, 2019). Takala, Malmi, Pugliese & Takala (2016) found that with gradually increased technology integration, the students demonstrated better understanding and higher quality of VR application development. If a pre-training module is used to get students familiar with all the technologies through practices (e.g., creating a virtual tour using Google Tour Creator®) then, during the live session, students will be able to focus more on the collaborative inquiry activity rather than learning about the technology tool from scratch.

The findings were also in line with the claim that student-to-student and instructor-to-student interaction in the Zoom breakout room were less effective than classroom interactions (de Oliveira Dias, Lopes & Teles, 2020). Students in the current study missed the opportunity to talk to neighboring students for information clarification (e.g., instructor’s instructions, G Tour creator steps). Online students were forced to take an individual-controlling pattern (e.g., one screen share) while the classroom students had more freedom to switch between the individual-controlling and collaborative group-controlling pattern (e.g., checking and discussing multiple teammates’ screens). This finding contradicts the comparison between online and classroom group interaction in Shu and Gu’s (2018) study, where the online interaction in online forum is more group-controlling while classroom interaction of in-class discussion is more individual-controlling.

Compared to the classroom group, the online students in the current study had more challenges deciding the group arrangement, members’ role and responsibilities, e.g., who will share the screen while labeling sites in the Google Tour Creator. The challenges of online group work were in line
with previous studies that online students perceived online collaboration helpful but they viewed it as the least favorite thing to do in online class (Chang & Kang, 2016; Thomas & Thorpe, 2019).

Third, online students had more challenges than the classroom students during the VR inquiry learning activity, which calls for proactive instructional design for meaningful VR integration in the online learning environment. For future technology design, the findings of students’ perceptions and challenges with both VR and online learning platforms demand more collaboration-friendly VR and online conferencing tools. The challenge of using technology for real-time collaborative work made it harder for students to work in groups online. In this study, Google Tour Creator® does not afford real-time collaboration like Google Docs®, and Zoom® does not support students to view other students’ screens simultaneously. Future online learning technology should allow for group interactions, where students can easily turn to other classmates to check on their screens for project progress and have engaging conversations.

There were still some limitations to this study. The online students were not able to access VR viewers (e.g., Google Cardboard®) for a full VR experience. In the future, the instructors can ship a VR viewer to students or set a course material requirement of purchasing a low-cost Google Cardboard® viewer. In addition, the small sample size in the study makes it hard to be generalized. Future research should consider a larger scale and include students from different disciplines to offer additional insights about VR inquiry-based learning.

**Conclusion**

This study offers insights for the educators, instructional designers, researchers and administrators about the adoption of a VR activity on students’ performance and perceptions. The study contributes to the literature by exploring the challenges of VR integration in an online course setting during COVID-19. The instructional design and delivery of the VR learning activity greatly influenced the students’ learning experiences, rather than the VR technology itself. Future VR integration should consider a pre-training to make sure students are comfortable with the VR
technology before jumping into the VR course activities. Future research should also draw on the students’ prior knowledge and experiences in online learning to ensure the students are aware of the best practices of learning and collaborating in online learning environments.


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Table 1.

**Learning objectives for virtual reality activity**

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<th>Step</th>
<th>Procedure</th>
<th>Learning Objective</th>
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<td>1</td>
<td>Introduction to Google Tour Creator</td>
<td>Access tour creator web-site, explore a sample hospital room, and learn how to label points of interest.</td>
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<tr>
<td>2</td>
<td>Pre-test</td>
<td>Identify all the most common infectious sites in the hospital room.</td>
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<tr>
<td>3</td>
<td>Small groups of students review EBP articles</td>
<td>Write an annotated bibliography about the infectious sites mentioned in the hospital (&lt; 150 words) and site the article using APA format.</td>
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<tr>
<td>4</td>
<td>Create a VR tour</td>
<td>Upload a 360-picture of the hospital room provided.</td>
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<td>5</td>
<td>Points-of-Interest</td>
<td>Label points-of-interest using sites identified in evidence based-practice articles and using an APA citation.</td>
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<td>6</td>
<td>Interventions</td>
<td>Discuss at least three nursing interventions for sanitization related to infectious sites identified in evidence based-practice articles.</td>
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<tr>
<td>7</td>
<td>Post-test</td>
<td>Identify all the most common infectious sites in the hospital room after reviewing evidence-based practice articles.</td>
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