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ORIGINAL PAPER

Utilizing virtual reality before, versus during, the COVID-19 pandemic

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Abstract

As the COVID-19 pandemic abruptly pushed interior design (ID) instruction online, instructors were challenged to adapt, and students adapted a new method of virtual reality (VR). The VR method before COVID-19 was a Homido V2 VR headset with iPhone viewing 360-degree panorama jpeg, and during COVID-19 a liquid crystal display (LCD) computer monitor viewing 360-degree panorama jpeg. The *purpose* of this study was, if a statistically significant difference (SSD) in *spatial presence* was found between the two types of VR, then an argument could be supported to evaluate *spatial presence,* before VR is implemented into ID curriculum. This study was at one Midwestern United States university with a sample ($N = 52$) of ID undergraduate students. The results revealed an SSD in the *spatial presence* in the aforementioned VR types. This SSD was found in two of the three dependent variables: Spatial Presence: Possible Action (SPPA; $U = 772$, $p < 0.001$), example survey question *feeling you could jump into the action,* and Spatial Presence: Self Location (SPSL; $U = 789$, $p < 0.001$), example *feeling you are in the middle of the action*. The third dependent variable, Spatial Situation Model (SSM; $U = 1320$, $p = 0.834$) did not reveal an SSD, example *imagining the arrangement of the spaces.* To support results, the Virtual Reality Spatial Presence Index (VRSPI) applied scored *neutral (*neither *strong*, nor *weak)* for *spatial presence* in both. This study filled research gaps on VR spatial presence measurement, with implications supporting a measurable advantage in ID students using VR headsets and ID curriculum developers evaluating VR before implementation.

Keywords Virtual reality · Interior design · Spatial presence · COVID-19 pandemic · Education · CIDA

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Abbreviations
MR Mixed reality
VR Virtual reality
DE Desktop environment
VE VR environment
HE Hybrid design environment

Introduction

In 2022, an influx of researchers studied the effects, including *spatial presence*, of virtual reality (VR) use in interior design in both instruction and practice (Kahrl et al. 2021; Guevara et al. 2022; Jin et al. 2022; Kim et al. 2022; Mejia-Puig and Chandrasekera 2022; Vahdat 2022). This topic becomes increasingly important, possibly fueled by the COVID-19 pandemic pushing in-person interior design education causing a shift in the methods of VR and also due to a rapidly changing field of VR. Some researchers have already studied the shift (Ahmad et al. 2020; Basil-Mohammed et al. 2021; Lili and Jiping 2021).

With researchers requesting more studies into spatial presence during VR use and effects of the COVID-19 pandemic on interior design instruction, this study highlights the problem of VR needing to be evaluated before inclusion into interior design curriculum. The pandemic pushed in-person VR headset use, (see Fig. 1), to online interior design instruction, where instructors sought an alternative, such as the students using a liquid crystal display (LCD) computer monitor viewing a 360-degree panorama jpeg (see Fig. 2). The above mentioned acted as the two independent variables for this study, and the sensation of spatial presence acted as the dependent variable for this study. For the purpose of this study, *spatial presence* was defined as the user consciously experiencing the sensation of presence based on a cognitive feeling and an unconscious process (Wirth et al. 2003).

Fig. 1 Homido V2 headset

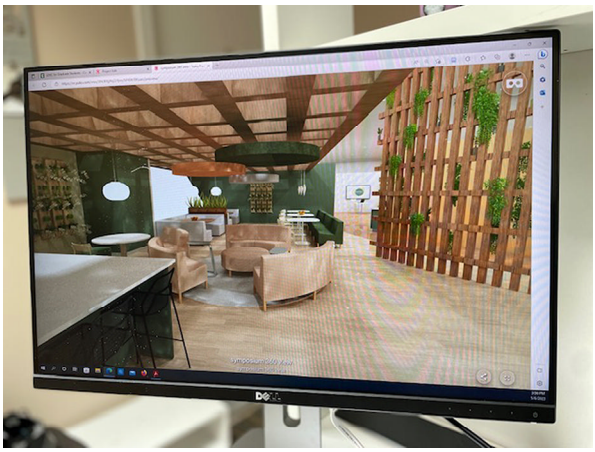

Fig. 2 Liquid crystal display (LCD) computer monitor viewing a 360-degree panorama jpeg

The research shows VR has been established as an important tool in design. For example, in architectural firms, Yulio 360-degree panorama VR, viewed on an iPhone with a Samsung Gear or Homido V2, is currently being used in firms such as Gensler, ALSC Architects, Diamond Schmitt Architects, and Ronen Beckerman (Chan n.d.). Per Diamond Schmitt Architects, this type of passive VR (mobile Yulio VR) "worked better for us because it gave us the opportunity to communicate through every day, accessible objects like smartphones" (Chan n.d. para. 1). In addition, a peer-reviewed study survey indicated "participants most frequently cited virtual reality (39%)" when asked for the largest growth area of technology use (Huber and Waxman 2019, p. 14). To tie this to interior design education, an Interior Design Educators Council (IDEC) conference included a panel discussion of trends in interior design education. Of the six interior design programs they all wanted to introduce Virtual Reality (Swearingen 2019). In summary, VR is beginning to be used by employers who hire interior design graduates. Jin et al. (2022) reminded us to consider the limitations of the VR and examined these limitations such as realistic, confusion, blurry, dizziness, among others (p. 47).

Continuing the research of Jin et al. (2022), the *objective* of this present study was to determine if there was a statistically significant difference (in the variable *spatial presence)* between the two types of VR: a Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg and, during COVID-19, a liquid crystal display (LCD) computer monitor viewing the same 360-degree panorama jpeg. The same VR scene was used in both VR formats. To create the VR scene, it was first drawn in a CET Designer, a .cmdwr file, then was rendered as a 360-degree .jpg (cube map), and last imported into Yulio, a 3rd party VR application. This same scene was displayed on both independent variables, the Homido V2 VR headset viewing iPhone and the LCD monitor. This study's results revealed quantitative data collected from a sample (N = 52) of interior design undergraduate students who experienced both types of VR. The results sought a statistically significant difference between the two types of VR. The *purpose* of this study was to determine the difference between *spatial presence* in two types of VR to determine if VR should be evaluated for *spatial presence* before implementation into interior design curriculum.

Next, the literature review supported this argument by studying these topics: VR as an important tool in interior design, the COVID-19 pandemic had an effect on interior design education in regard to VR tools, the Council for Interior Design Accreditation's (CIDA) Standards should be evaluated for if they were compliant during the COVID-19 pandemic, spatial presence, during VR use, can be evaluated with an index to a applies a rating from *very strong* to *very weak.*

Literature review

Four topics critical to supporting the measurement of interior design students' perceived *spatial presence* while they used virtual reality (VR) were:

1. interior design with VR equipment use,
2. interior design and its' education during the COVID-19 pandemic,
3. interior design and the Council for Interior Design Accreditation's (CIDA) required Standard 7b. *Human-Centered Design: "Interior designers apply knowledge of human experience and behavior to designing the built environment"* (CIDA 2022, p. II-20). Standard 7b. clarified *"This could include natural, built, virtual, and/or technological environments"* (p. II-21)., and last,
4. the link between virtual reality and spatial presence and how it can be evaluated with an index.

The gaps revealed in the literature review were: VR use in interior design has varying results and needs to continue to be studied, the COVID-19 pandemic limited interior design education and researchers are still studying the effects, and how can researchers continue to support the Council for Interior Design Accreditation's (CIDA) goal to help interior design students design the built environment to support human experience and behavior. The literature review culminated in a compelling argument for the importance of data collection and data analyzation of *spatial presence* while interior design students are using VR.

Interior design and virtual reality use

Virtual reality (VR) is the term meaning to generate the illusion of being somewhere else. Interior design and VR use can be very helpful in this profession. It can allow designers, as well as clients, to view a space in more depth and give a better visualization of what a space will look like when it is completed. According to Jin et al. (2022) and their research with VR technologies, VR is powerful, but has limitations needed to be reached and will never replace real experiences. VR technologies are not supposed to replace the real-life experience of viewing a site, but they can assist a client or a student in giving a better representation of what to expect with a finished product.

Kahrl et al. (2021) did research on Mixed Reality (MR), a very similar concept to VR, however adds an element of your physical space, sometimes referred to as natural space, VR technologies to see which was preferred by participants.

> We also found that all of the Mixed Reality (MR) mechanisms were perceived better than providing photos of the living room. We concluded that for tasks like ours, PC-based VR might be most favored by potential users, but because of its high price and low availability in people's homes, a combination of mobile devices and mobile VR might be most favorable. (p. 246)

VR was preferred by most over MR, but it was harder to get their hands on because of the higher cost of the technologies. Having VR on mobile devices will also allow everyone to view scenes from anywhere, thereby making them more accessible.

An alternative form of VR is what is referred to as a fish tank view (Astle 2022). Fish tank view defined as a 360-degree VR view not requiring a headset. Arstle explained the positives and negatives, but supported that fish tank view is a powerful tool for viewing a VR scene. They also stated though it does not add depth and immersion to the experience, it can still be an extremely powerful tool to can make an impact. This point became important to interior design students when the COVID-19 pandemic started.

Interior design and COVID-19

Just like all other students, interior design majors had to find a way to navigate around the challenges of switching to online learning during the COVID-19 pandemic. "The COVID-19 pandemic is making the pedagogy profession rethink education, not only through implementing the known but also by discovering new potentials within interior design education" (Ahmad et al. 2020, p. 178). The researchers continued to discuss limitations and missed opportunities. Students looking to go into this profession have had to miss out on a lot of real-life experiences and hands-on learning during their semester due to the pandemic shutting down businesses. Mohammed et al. (2021) agreed with this point of view in saying:

> The problem with distance education is brought about when assessing its effectiveness. Does this mean that our students and teachers get the best education experience using this method? Especially for practical courses. Findings taken from the Grade 1 class at TIU prove that students and teachers were not adjusting well to online courses when it came to practical classes as compared to theoretical ones. (p. 195)

In other words, the researchers were observing the effect distance learning was having on interior design students and their instructors. They found both students and instructors did not find online learning as effective in teaching the necessary material as in-person classes were. Interior design students were selected for this study because they do a lot of hands-on work in their studio classes to get a better understanding of how to draw plans and observe all the components going into buildings. On the other hand, Lili and Jiping (2021) disagreed and found online learning as beneficial to students as they are exposed to new teaching methods pushing students' thinking. They also believe online teaching, due to the pandemic,

will break the traditional mold of in-person classes and allow students to better use the assets given to improve themselves.

Interior design and Council for Interior Design Accreditation (CIDA)

The Council for Interior Design Accreditation (CIDA 2022) is a non-profit accrediting program for interior design programs at universities and colleges located in the United States and internationally. Albadi and Zollinger (2021) did a study among interior design CIDA accredited programs to see how a certain generation (Generation Z) of students see their learning styles:

> The most common learning style found was the combination of Concrete Random and Abstract Random (i.e., learners who are emotional and imaginative and enjoy holistic experiences with trial and error approaches and exploration)…The second most common learning style was the unimodal Concrete Sequential (i.e., students who enjoy experiential activities and step-by-step processes). (p. 49)

The researchers did this to assist professors to improve instruction in the classroom setting. This also helps the professors develop lesson plans for student understanding and retention. According to CIDA Professional Standards (2022), learning expectations for students should include students having awareness of the origin/intent of laws, codes, and standards; students' demonstrating the understanding of standards and guidelines related to sustainability and wellness, and students implementing regulations and guidelines related to construction, products, and materials. Finally, students work should apply federal, state, and local codes including fire and life safety, and barrier-free and accessibility regulations and guidelines. With the knowledge from Albadi and Zollinger's research (2021), professors at universities will be able to use tools to help students achieve these standards.

Relating CIDA's standards in interior design education, to VR use, an Interior Design Educators Council (IDEC) conference included a panel discussion of trends in interior design education. Of the six interior design programs, "all of the programs wanted to introduce Virtual Reality" (Swearingen 2019, p. 16). IDEC explores trends in interior design education and also CIDA standards as they relate. One of the standards, 7b, simply put focuses on how the interior design student designs the built environment considering human experience and behavior. This CIDA Standard reads 7b. *Human-Centered Design: "Interior designers apply knowledge of human experience and behavior to designing the built environment"* (CIDA 2022, p. II-20). Standard 7b. clarifies *"This could include natural, built, virtual, and/or technological environments"* (p. II-21).

Virtual reality and spatial presence

Wirth et al. (2003) denote spatial presence can be defined as the sense of being in an environment, which is an important factor when using VR equipment. VR helps to show a more realistic view of space to get a better representation of what

a client's space will look like once it is finished. However, different things can interfere with how spatial presence is perceived by the user. Denzer et al. (2022) researched how using bizarre dreamlike states in VR would affect the spatial presence of the participant. "Inducing experience of bizarreness and unreality did not interfere with spatial presence, the 'feeling of being there' in the virtual world, such that spatial presence was high and similar in both conditions" (Denzer et al. 2022, p. 12). It was concluded from their findings when changing the overall experience of the participant it did not affect how "in-depth" they felt in the virtual world.

To measure *spatial presence* Vorderer et al. (2004) developed the Measurements, Effects, Conditions Spatial Presence Questionnaire (MEC-SPQ). This survey has Cronbach alpha scores from 0.86 to as high as 0.91, supporting high reliability in the survey. Other researchers (Pérez and Escobar 2019; Yildirim et al. 2019; Guevara et al. 2022) also utilized the MEC-SPQ to measure spatial presence while using a virtual media. Guevara et al. (2022) also found a statistically significant difference between perceived spatial presence when comparing three formats of VR using this same survey. The MEC-SPQ was incorporated into this study because of its strength in finding variances in quantitative survey results. The questionnaire "was designed for immediate assignment after media exposure" (p. 4), which lent itself to this methodology design where the participants were offered time enough to take the survey after exposure to each VR.

To support the validity of collecting data on spatial presence, researchers (Guevara et al. 2020) have developed an index to evaluate a user's perceived *spatial presence* while viewing a scene in VR. This index is the Virtual Reality Spatial Presence Index (VRSPI) and has been used in peer-reviewed research to evaluate other formats of VR on a 5-point scale from *very strong* to *very weak.* For example, Guevara (2022) evaluated three formats of VR (viewing the same scene) and found the three to vary from *slightly strong* (Oculus Rift viewing Unity), to *neutral* (DLP technology shutter glasses (XPAND Edux3) with VR cube viewing Unity, to *slightly weak* (Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg). See Fig. 3.

Literature review conclusion

Researchers agreed VR is the term used to generate the illusion of being somewhere else and adding VR technology to university education of interior designers is an opportunity to support student-centered learning for 3-dimensional design development. However, analyzing the capabilities of the VR display formats can give insight into which technology is the most effective tool to support students' human sensory experiences. VR formats have already started to be evaluated and their differences measured in regard to *spatial presence.* The literature review supported this argument in four ways:

1. virtual reality (VR) use remains an important tool in interior design education;
2. the COVID-19 pandemic had an effect on interior design education in regard to VR tools;

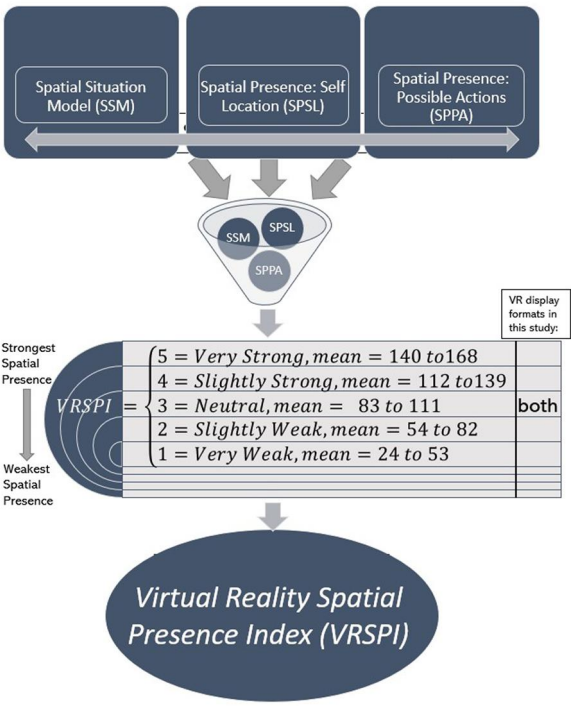

Fig. 3 Virtual Reality Spatial Presence Index (VRSPI) applied to VR study

3. the Council for Interior Design Accreditation's (CIDA) Standards should be evaluated for compliance during the COVID-19 pandemic, to support additional studies such as studies reported on interior design students' competencies as being tied to CIDA requirements in interior design education (Albadi and Zollinger 2021; CIDA 2022);
4. an index should be applied to a VR spatial presence measurement, from *very strong* to *very weak.*

Since VR is an emerging and ever-changing technology, it is important to supplement the research with an ongoing comparison of VR display formats, in particular as interior design education makes shifts.

Methodology

This methodology includes the research design, the variables, prevention of study threats and recruitment of sample. A methodology summary at the end of this section leads to the subsequent section, which reveals the study results.

Research design

The design of the research utilized was a quantitative study using an exploratory, 5-point Likert-style survey (Appendix A) on a sample (N = 52) of interior design

undergraduate students. This quantitative research design supported the strength in the relationship between the variables. A quantitative exploratory study was appropriate for this, due to the type and quantity of variables which were required to produce a data set appropriate for the inferential statistical Mann-Whitney Test—i.e., two independent variables (VR display formats: Headset and Monitor) and three dependent sub-variables (spatial presence capabilities: SSM, SPSL, and SPPA). The advantage was that this type of analysis helped seek where and if statistically significant difference were found, so that we could support (or not support) the hypotheses.

The surveyed sample included four levels of interior design undergraduate students at one university and their perceived experience with two VR display formats. These formats were available through the institution and have been used in instructing interior design students on this campus. Interior design students were selected as the study participants because in their current curriculum incorporates independent variable one, the VR display format of Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg. Both VR displayed the same interior design student-developed scene. Hypotheses were:

- H1: There will be a statistically significant difference between the interior design students' perceived spatial presence capabilities of the two VR display formats.
- H2: There will be no statistically significant difference between the interior design students' perceived spatial presence capabilities of the two VR display formats.

Variables

The independent variable one was the VR display format of Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg. The independent variable two was a liquid crystal display (LCD) computer monitor viewing the same 360-degree panorama jpeg. This VR scene viewed in both VR formats was created first in a CET Designer .cmdwr file, then was rendered as a 360-degree .jpg (cube map), and last imported into Yulio, a 3rd party VR application. The dependent variable was the VR's spatial presence capability, as perceived by the sample. The variable held constant was the scene viewed within both independent variables one and two. This view was drawn in the software CET Designer and rendered into a 360-degree panorama jpeg

These independent variables were selected in order to seek if interior design curriculum developers should be concerned about the change in VR curriculum during the COVID-19 pandemic. The dependent variables were selected since these variables showed reliability in revealing a statistically significant difference in both the pilot study (Guevara et al. 2022) and another study performed by this author using the same dependent variables (Guevara and Bogedain 2022).

Reliability and validity

Reliability was supported by utilizing the pre-validated MEC-SPQ (Vorderer et al. 2004). This survey has Cronbach alpha scores as low as 0.86 and as high as 0.91; this equates to high reliability. Since a survey is pre-validated, this assisted the researcher to minimize the threats to the reliability of the study. The important of reliability is that the study can be replicated by other researchers and assured a consistency in the measurements when the study is repeated in the future. "Designed for immediate assignment after media exposure" (Vorderer et al. 2004, p. 4), the survey was completed immediately after the sample experienced independent variables one and two. The survey was designed with 5-point Likert scale. The survey instrument can be found in Appendix A. Construct validity was supported by displaying the same interior design scene in both independent variables one and two. Since the data collection tool had content validity, the tool measured what it was intended to measure. Also, since the mentioned topics supported both the reliability and validity of this study, then our study objective was met. The objective was to determine if there was a statistically significant difference (in the variable spatial presence) between the two types of VR.

Sample

The study was announced one month prior by a non-participant study member. The sample (N = 52) was interior design undergraduate students from a Midwestern United States university interior design program. The sample came from the following courses, Freshmen Studio 1 (n = 21), Sophomore Studio 3 (n = 10), Junior Studio 5 (n = 7) and Senior Studio 7 (n = 14). Non-reported variables were race, age, sex, and ethnicity. Consent materials were offered one week prior to data collection, after which students voluntarily participated.

Human subjects approval and consent

A human subjects approval was secured three months prior to data collection. Study variables, methodology and constraints were included in the human subjects approval. To ensure human subject privacy, no names were collected in the study. See consent in Appendix B. See Institutional Review Board for approval in Appendix C.

Instrument for data collection

A quantitative data collection instrument was utilized in this study (Appendix A). The researcher collected quantitative data from the participants with the digital survey software Qualtrics, with an electronic copy of the MEC-SPQ survey with five Likert-scale responses from *strongly agree* assigned a score of 1, up to *strongly disagree* assigned a score of 5. To ease data analysis, the following three sub-variables were used:

- Spatial Situation Model (SSM) for Questions 2 through 9.
- Spatial Presence: Self Location (SPSL) for Questions 10 through 17.
- Spatial Presence: Possible Actions (SPPA) for Questions 18 through 25.

Collection of data

During August of 2022 to September 2022, setting up the data collection instrument was completed, student assistants were trained, and recruitment of subjects was completed.

Setup of data collection instrument

Both VR display formats, independent variables one and two, both showed the same interior design scene, completed prior to the study by an interior design student. This scene was created first in a CET Designer .cmdwr file, then was rendered as a 360-degree .jpg (cube map), and last imported into Yulio, a 3rd party VR application. Data collection was assigned to one room on campus, which was convenient to access. Pre-selected student assistants moderated each VR display format. In the case of a study participant experiencing motion sickness, one student assistant was available to assist, though no participant required assistance.

Set-up of variables

Independent variable one

One row of desks in the data collection room held independent variable one, the Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg. The jpeg resolution was 1536 × 1536 (Chan n.d.). No audio effect was included.

Independent variable two

The second row of desks consisted of desktop computers in the designated research room, and held independent variable two, liquid crystal display (LCD) computer monitor viewing the same 360-degree panorama jpeg. Each computer used the same monitor and showed the identical scene in the VR headset. Audio effects were not included.

Consent form

All student assistants collected signed consent forms prior to study participants participation.

Study recruitment and participation

Study recruitment began with the school director contacting the instructors of the courses to ask for permission to introduce the study. With prior approval from the instructors and school director, two student assistants verbally presented the research methodology, along with the consent. Participants chose to volunteer, signed the paper consent forms. As part of the consent process, participants were reminded that if motion sickness occurred, they should ask to end their intervention and they would not be negatively impacted by the decision.

The intervention spanned over a course of three months, with participants escorted to and from their class to the data collection room housing independent variables one and two. Upon arriving, participants would take a seat in the room, divided equally between the two rows. The participants viewed the first VR display format for 45 s. To signal the end of the viewing, the moderator tapped the participant on the shoulder to designate the 45 s end and directed the participant to complete the electronic survey. Participants were asked to finish incomplete surveys and then proceeded to the second VR display format. This process repeated until the participant completed both displays and both surveys. Once participants had finished viewing the displays and being surveyed, the participants were excused.

Pilot study

A pilot study (Guevara et al. 2022) was reviewed and reported to support the validity of this study. The pilot study was performed prior to this study. The pilot study pre-tested the variables with a smaller sample ($N = 33$). The pilot study also used the data collection tool the Measurements, Effects, Conditions Spatial Presence Questionnaire (MEC-SPQ; Vorderer et al. 2004). The MEC-SPQ survey gathered data from the sample on perceived spatial awareness while experiencing a virtual environment. The same three dependent sub-variables were used in both the pilot study and this study. Though the independent variables were different (VR type). The pilot study results found that the independent variables of VR types A, B, and C did have statistically significant differences with each of the three dependent sub-variables.

Methodology summary

This quantitative methodology utilized the strength of a pre-validated instrument with a high Cronbach alpha score, while supporting both reliability and validity. The human subjects' approval and consent assured the safety and privacy of the 52 participants. In addition, training of the student assistants ensured accuracy in the data collection process as well as the safety of the study participants.

Results and data analysis

The results section includes and reviews the descriptive statistics, the data analysis process and the data analysis results.

Descriptive statistics

The study sampled ($N = 52$) interior design undergraduate students from four levels of interior design studio courses. Participants, by course level, were Freshmen Studio 1 ($n = 21$), Sophomore Studio 3 ($n = 10$), Junior Studio 5 ($n = 7$) and Senior Studio 7 ($n = 14$). See Table 1.

The study sampled the 52 interior design undergraduate students for their perceived experience while viewing the same interior design scene, but viewed in two different VR display formats. The first VR format was the Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg. The second VR format was the liquid crystal display (LCD) computer monitor viewing the same 360-degree panorama jpeg. When applying the VRSPI to this study, the study participants ($N = 52$) evaluated the first format (headset) with a combined mean score of 99.62. The second format (Monitor) was evaluated with a combined mean score of 87.04. See Fig. 4.

Virtual Reality Spatial Presence Index (VRSPI) applied to VR study

As mentioned in the literature review, the Virtual Reality Spatial Presence Index (VRSPI; Guevara et al. 2020) is an effective way to measure and evaluate the

Table 1 Frequency table: participants by course level

Course level	Frequency	Percent	Cumulative percent
Freshmen studio 1	21	40.39	40.38
Sophomore studio 3	10	19.23	59.62
Junior studio 5	7	13.46	73.08
Senior studio 7	14	26.92	100.00
Totals ($N = 52$)	52	100	

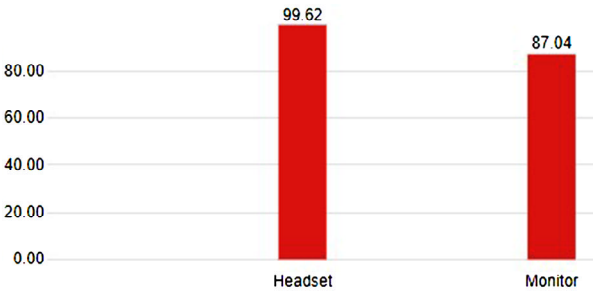

Fig. 4 Headset and Monitor: Combined Mean Score

overall perceived *spatial presence* of a VR format when a comparison to another VR format is needed. This was the case in this study, where we needed to compare the VR utilized prior to the COVID-19 pandemic to the VR used during the COVID-19 pandemic, in interior design instruction. Applying the VRSPI to this study, both VR formats would be assigned VRSPI = 3 *neutral.* Refer back to Fig. 3.

Inferential statistics interpretation

Inferential statistics were analyzed in two steps, the Mean Rank and the Mann-Whitney Test. The first step reported and analyzed the Mean Rank. The group with the highest Mean Rank was the Headset group in SPSL and Headset group in SPPA, scoring 4.32 vs. 4.10 respectively. See Fig. 5 and Table 2.

The resulting data set was appropriate for the inferential statistical Mann-Whitney Test with two independent variables (VR display formats: Headset and Monitor) and three dependent sub-variables (spatial presence capabilities: SSM, SPSL, and SPPA).

The Mann-Whitney Test was conducted to determine whether there is a difference in SSM, SPSL, and SPPA scores between Headset/Monitor. The results indicated statistically significant differences between Headset/Monitor for SPSL ($U = 789$, $p < 0.001$) and SPPA ($U = 772$, $p < 0.001$) groups, but **not** for SSM groups ($U = 1320$, $p = 0.834$). Simply put, there **was** a difference in how the user felt items in the scene surrounded them and how much a part of the scene the user feels (SPSL), as well as, there **was** a difference in whether the user feels they could jump

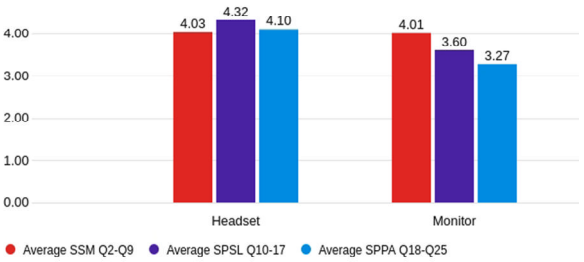

Fig. 5 Mean rank scores for each variable: SSM, SPSL, SPPA

Table 2 Mean rank scores for each variable: SSM, SPSL, SPPA

	Monitor or headset?	*N*	Mean rank
SSM_avg_Q2-Q9	Headset	52	4.03
	Monitor	52	4.01
	Total	104	
SPSL_avg_Q10-Q17	Headset	52	4.32
	Monitor	52	3.6
	Total	104	
SPPA_avg_Q18-Q25	Headset	52	4.1
	Monitor	52	3.27
	Total	104	

into the action and how well the user felt they could be active in the scene (SPPA). In contrast, there **was not** a difference in how well the user can remember the scene and how well the user can understand how far apart items are in the scene (SSM). See Table 3.

Inferential statistics interpretation conclusion

Simply put, the results revealed three major conclusions.

1. There was a difference in how present one feels, with stronger spatial presence felt while viewing the same scene in the headset, versus viewing the scene in a 360-degree view. This stronger spatial presence was felt in the headset in Spatial Presence: Self Location (SPSL). One example survey question was *"I had the feeling that I was in the middle of the action rather than merely observing*" (Vorderer et al. 2004, p. 8). This stronger spatial presence was also felt in the headset in Spatial Presence: Possible Action (SPPA). One example survey question was "*I felt like I could jump into the action*" (p. 9).
2. The variable with no spatial presence difference was Spatial Situation Model (SSM). One example survey question was "*I was able to imagine the arrangement of the spaces presented in the scene very well*" (p. 7).
3. When the VRSPI (Guevara et al. 2020, p. 259) was assigned to Headset and Monitor, both VR formats were assigned VRSPI = 3 *neutral.* Simply put, neither the headset nor the monitor had *strong*, nor *weak* spatial presence.

To support the validity of this study, a previous study also found the same Homido V2 VR headset with an iPhone viewing 360-degree panorama jpeg. with a VRSPI = 2 *slightly weak* spatial presence (p. 261). The same study, however, compared and found the Oculus Rift with a VRSPI = 4 *slightly strong* spatial presence (p. 261).

Discussion/conclusion

The key findings of this study supported the headset utilized for VR does in fact provide increased spatial presences for the user for two of the dependent variables Spatial Presence: Self Location (SPSL) and Spatial Presence: Possible Action (SPPA). Example survey questions "*I had the feeling that I was in the middle of the action rather than merely observing*" (Vorderer et al. 2004, p. 8) and "*I felt like*

Table 3 Mann-Whitney: differences between the groups (headset and monitor) are statistically significant for SPSL and SPPA, but not for SSM

	SSM_add_q2q9	SPSL_add_q1017	SPPA_add_q18q25
Mann-Whitney U	1320	788.5	772
Wilcoxon W	2698	2166.5	2150
Z	−0.209	−3.675	−3.777
Asymp. Sig. (2-tailed)	0.834	<0.001	<0.001

I could jump into the action" (p. 9), respectively. This study followed the shift in VR taught before and during the COVID-19 pandemic, and its effect on spatial presence felt. The sample (N = 52) of interior design Midwestern United States university undergraduate students provided the data which revealed the results, that in fact, supported the *objective* of this study. The results revealed a significant difference in the *spatial presence* felt in two out of the three dependent variables; Spatial Presence: Possible Action (SPPA) (U = 772, p < 0.001) and Spatial Presence: Self Location (U = 789, p < 0.001). Example questions being *feeling you could jump into the action* and *feeling you are in the middle of the action*, respectively. The third dependent variable, Spatial Situation Model (U = 1320, p = 0.834) did not reveal a difference. Example question being [I am] *imagining the arrangement of the spaces*. The researchers speculated that the reason that no significant difference was found in the third dependent variable is that the study participants being interior design students, are already adept at imaging the arrangement of spaces.

In addition, to support the results, the Virtual Reality Spatial Presence Index (VRSPI) was applied and both VR formats scored *neutral (*neither *strong*, nor *weak)* for *spatial presence*. Since the *purpose* of this study was if a statistically significant different *spatial presence* was found between the two types of VR, then an argument can be supported before VR is introduced into interior design curriculum, and it should be evaluated for perceived *spatial presence*. The implications of the findings that supported that VR headset use by interior design students has a measurable advantage in learnings over VR use without headset use. For future research, interior design curriculum developers should evaluate the type of VR prior to implementing into curriculum. This could guide future interior design curriculum development and how it could guide instructional strategies.

This study filled the gap of research needed on spatial presence measurement during VR use. Before a new technology is introduced into instruction and curriculum, typically there is a driving force such as the industry progressing and the curriculum developers meeting the need of the changing industry. In the case of the Covid-19 pandemic, interior design instruction had no choice but to shift to online instruction, so instructors sought a method of teaching how to utilize VR.

Study limitations must be revealed in all studies. The limitations in this study were, but not limited to:

1. It is unknown which study participants previously (prior to this study) utilized either of the independent variables (VR).
2. It is unknown if study participants discussed their opinions with other participants.

Since interior design instruction includes virtual environments, this study examined the research question: is there a statistically significant difference between the virtual environments utilized prior to the COVID-19 pandemic, headset, and the interior design instructor's solution to "virtual" during the COVID-19 pandemic, liquid crystal display (LCD) computer monitor viewing the same 360-degree panorama jpeg? Spatial presence, simply meaning how present do you feel while you are in a virtual environment? Wirth et al. (2003), defined spatial presence as the

user consciously experiencing the sensation of presence, based on a cognitive feeling and an unconscious process.

The direct impact this study' results could directly relate to interior design students' future ability to improve their learnings. VR assists students, any type of student, to retain information, comprehend information and spatial presence has been shown to increase learnings. When evaluating VR, researchers can assist interior design educators determine which VR to add to their curriculum, as well as professional already in practice. If educators start incorporating this measurement now, then current students will benefit. The current student will eventually be professionals taking this knowledge into professional practice.

Spatial presence is an essential concept for interior designers when using technology to view a project or a space. This allows both the students in their learning journey, as well as designers in the field, to get more knowledge of how the space feels without the need to be on site; however, technologies change, education delivery changes and human experience and behaviors change. This research is the platform of how we are educating the future generation of interior designers. To support this study, future researchers could identify additional interior design VR user perceptions, such fatigue, relaxation or how close the initial VR experience matches the interior design end in the physical world.

Appendix A: Survey

Q1 Course
- ○ CHOOSE ONE (5)
- ○ Freshman Studio 1 (1)
- ○ Sophomore Studio 3 (2)
- ○ Junior Studio 5 (3)
- ○ Senior Studio 7 (4)

Q2 I was able to imagine the arrangement of the spaces presented in it very well.
- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly agree (5)

Q3 I had a precise idea of the spatial surroundings presented it.
- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q4 In my mind's eye, I was able to clearly see the arrangement of the objects presented.
- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)

- ○ Slightly disagree (4)
- ○ Slightly disagree (5)

Q5 I was able to make a good estimate of the size of the presented space.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q6 I was able to make a good estimate of how far apart things were from each other.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q7 Even now, I still have a concrete mental image of the spatial environment.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Strongly disagree (4)
- ○ Strongly disagree (5)

Q8 Even now, I could still draw a plan of the spatial environment in the presentation.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q9 Even now, I could still find my way around the spatial environment in the presentation.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q10 I had the feeling I was in the middle of the action rather than observing.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)
- ○ Strongly disagree (5)

Q11 I felt I was a part of the environment in the presentation.

- ○ Strongly agree (1)
- ○ Slightly agree (2)
- ○ Neutral (3)
- ○ Slightly disagree (4)

- Strongly disagree (5)

Q12 I felt like I was actually there in the environment of the presentation
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q13 I felt like the objects in the presentation surrounded me.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q14 It was as though my true location had shifted into the environment.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q15 It seemed as though myself was present in the environment in the presentation.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q16 I felt as though I was physically present in the environment in the presentation.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q17 It seemed as though I actually took park in the action of the presentation.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q18 I felt I could jump into the action.
- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q19 I had the impression that I could act in the environment of the presentation.
- Strongly agree (1)
- Slightly agree (2)

- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q20 I had the impressing I could be active in the environment of the presentation.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q21 I felt I could move among the objects in the presentation.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q22 The objects in the presentation gave me the feeling that I could do things with them.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q23 I had the impression that I could reach for the objects in the presentation.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q24 It seemed to me that I could have some effect on things in the presentation, as I do in real life.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Q25 It seemed to me that I could do whatever I wanted in the environment of the presentation.

- Strongly agree (1)
- Slightly agree (2)
- Neutral (3)
- Slightly disagree (4)
- Strongly disagree (5)

Appendix B: Informed consent form

RESEARCH @ EMU

Informed Consent Form

Project Title: Virtual Reality During the COVID19 Shutdown of Interior Design Instruction
Principal Investigator: Diane Guevara, Eastern Michigan University
Co-Investigator: n/a
Faculty Advisor: n/a
Sponsor: n/a

Invitation to participate in research

You are invited to participate in a research study. In order to participate, you must be a construction management student or interior design student or a practicing construction manager. Participation in research is voluntary. Please ask any questions you have about participation in this study

Important information about this study

- The purpose of the study is: to determine the participants' perceived spatial presence on the Virtual Reality Spatial Presence Index (VRSPI), while viewing one virtual reality scene in two devices:
  - VR Homido headset viewing iPhone,
  - 360-degree VR viewing on a liquid crystal display (LCD) monitor sometimes referred to as fish tank viewing.
- Participation in this study involves a visit to Roosevelt room 201, viewing of virtual reality, and completion of two computer surveys.
- Risks of this study include:
  - motion sickness,
  - potential loss of confidentiality.
- The investigator will protect your confidentiality by:
  - not asking for personal information,
  - keeping confidential survey answers in a password protected Qualtrics file.
- Participation in this research is voluntary. You do not have to participate, and if you decide to participate, you can stop at any time.

What is this study about?

spatial presence is the user consciously experiencing the sensation of presence or simply put "how present do you feel in an environment?" and can be measured using the

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Measurements, Effects, Conditions-Spatial Presence Questionnaire. Participants will experience one virtual scene in two devices:

- 360-degree VR viewing on a liquid crystal display (LCD) monitor sometimes referred to as fish tank viewing.
- VR Homido headset viewing iPhone and then

Participants will complete the questionnaire after each view.

What will happen if I participate in this study?

Participation in this study involves:

- a visit to Roosevelt room 201, viewing the virtual reality scenes, and completion of two computer surveys. Participants divided into two equal groups named Group 1 and Group2.
  - Step 1: while seated for 45 seconds, the participant will view 360-degree VR viewing on a liquid crystal display (LCD) Research assistant will advise time limit.
  - Step 2: confidentially online, the participant will complete the MEC_SPQ questionnaire regarding their experience. Participant to raise hand upon completion and research assistant will guide participant to next step.
  - Step 3: while seated for 45 seconds, the participant will view the same scene in the VR Homido headset viewing iPhone. Research assistant will advise time limit.
  - Step 4: confidentially online, the participant will complete the MEC_SPQ questionnaire regarding their experience. Participant to raise hand upon completion and research assistant will guide to exit the room.
  - Steps 1 through 4 take a total of approximately 25 minutes, within one visit.
  - In case of motion sickness, you may raise you hand to end the viewing and accompany you.
  - If case of you wish to be accompanied to Eastern Michigan University's health center, an assistant with a car will be on hand to drive you.

We **will not** learn information about your health as a part of this research.

We **will not** AUDIO/VIDEO record this study.

Randomization **will** occur:

- Study participants will be divided equally into two group.
- Group one will view the Pico headset scene first, complete the questionnaire, view the Homido headset second and then complete another questionnaire. scene two second.
- Group two vice versa.

What types of data will be collected?

- We will collect data about your: your perceived spatial presence while viewing the virtual reality scene.
- The following data **will not** be collected: RACIAL OR ETHNIC ORIGIN; POLITICAL OPINIONS; RELIGIOUS OR PHILOSOPHICAL BELIEFS; TRADE UNION MEMBERSHIP, GENETIC INFORMATION; BIOMETRIC DATA FOR THE PURPOSES OF UNIQUE IDENTIFICATION; HEALTH DATA; OR SEX LIFE OR SEXUAL ORIENTATION INFORMATION.

What are the expected risks for participation?

The primary risks of participation in this study are motion sickness and potential loss of confidentiality.

You do not have to answer any questions that make you uncomfortable or that you do not want to answer. If you are upset, please inform the investigator immediately.

Your survey responses will be processed by Qualtrics software and SPSS software for the purposes of measuring your perceived spatial presence while viewing virtual reality.

Are there any benefits to participating?

You will not directly benefit from participating in this research.

Benefits to society include contribution to the body of knowledge of Construction Management safety training.

How will my information be kept confidential?

We will not collect any person information, nor information that can identify you. Your responses will not have identifying information and will be kept in the PI's password protected file indefinitely.

Storing study information for future use

We **will** store your responses to study in the future. Your information will be labeled with a code and not your name. Your information will be stored in a password-protected and will be stored indefinitely.

- We will collect data about your: your perceived spatial presence while viewing the virtual reality scene.
- The following data **will not** be collected: RACIAL OR ETHNIC ORIGIN; POLITICAL OPINIONS; RELIGIOUS OR PHILOSOPHICAL BELIEFS; TRADE UNION MEMBERSHIP, GENETIC INFORMATION; BIOMETRIC DATA FOR THE PURPOSES OF UNIQUE IDENTIFICATION; HEALTH DATA; OR SEX LIFE OR SEXUAL ORIENTATION INFORMATION.

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Storing study information for future use

We **will** store your responses to study in the future. Your information will be labeled with a code and not your name. Your information will be stored in a password-protected and will be stored indefinitely.

We may share your information with other researchers without asking for your permission, but the shared information will never contain information that could identify you.

What are the alternatives to participation?

The alternative is not to participate.

Are there any costs to participation?

Participation will not cost you anything.

Will I be paid for participation?

You will not be paid to participate in this research study.

Study contact information

If you have any questions about the research, you can contact the Principal Investigator, Diane Guevara, at dguevara@emich.edu by phone at 617-320-9098. For questions about your rights as a research subject, contact the Eastern Michigan University Human Subjects Review Committee at human.subjects@emich.edu or by phone at 734-487-3090.

Voluntary participation

Participation in this research study is your choice. You may refuse to participate at any time, even after signing this form, without repercussion. You may choose to leave the study at any time without repercussion. If you leave the study, the information you provided will be kept confidential. We cannot destroy any information that has already been published.

Statement of Consent

I have read this form. I have had an opportunity to ask questions and am satisfied with the answers I received. I give my consent to participate in this research study.

Signatures

_____
Name of Subject

_____ _____
Signature of Subject Date

I have explained the research to the subject and answered all their questions. I will give a copy of the signed consent form to the subject.

_____
Name of Person Obtaining Consent

_____ _____
Signature of Person Obtaining Consent Date

Appendix C: Institutional review board approval

Date: 2-28-2023

IRB #: UHSRC-FY22-23-8
Title: Virtual Reality During the COVID19 Shutdown of Interior Design Instruction
Creation Date: 7-21-2022
End Date:
Status: Approved
Principal Investigator: Diane Guevara
Review Board: University Human Subjects Review Committee
Sponsor:

Study History

Submission Type Initial	Review Type Expedited	Decision Approved
Submission Type Modification	Review Type Expedited	Decision Approved

Key Study Contacts

Member Diane Guevara	Role Principal Investigator	Contact dguevara@emich.edu
Member Diane Guevara	Role Primary Contact	Contact dguevara@emich.edu
Member Suleiman Ashur	Role Investigator	Contact sashur@emich.edu

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Author contributions Conceptualization, D.G.; methodology, D.G.; software, D.G. and J.K.; validation, D.G.; formal analysis, D.G.; investigation, D.G. and J.K.; resources, D.G.; data curation, D.G. and J.K.; writing—original draft preparation, D.G. and J.K.; writing—review and editing, D.G. and J.K.; visualization, D.G.; supervision, D.G.; project administration, D.G. and J.K. All authors have read and agreed to the published version of the manuscript.

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Data availability Data supporting reported results can be retrieved by request from dguevara@emich.edu or at this data link Qualtrics Qsupport V2 Combined Monitor and Headset.

Declarations

Ethical approval (a) University Human Subjects Review Committee Approval (UHSRC) approval on July 7, 2022 for conducting human subject research, as defined by the Federal Government. The UHSRC consists of faculty members who volunteer their time and service. The UHSRC is composed of members from every College on campus as well as representation from the community (i.e., members who are not affiliated with EMU). UHSRC members serve 3-year terms with the option of renewal. All high-risk studies will be reviewed by the UHSRC. Human Subjects Protections-IRB - Research | Eastern Michigan University (emich.edu). (b) Research performed in accordance with the Federal Government. (c) No exemption granted.

Informed consent Informed consent was obtained from all participants for participation in the study. Informed consent displayed in Appendix B.

Competing interests The authors declare no conflict of interest, nor competing interests.

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