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Martha Snyder
Nova Southeastern University, smithmt@nova.edu

Steven Kramer
Nova Southeastern University, sk863@nova.edu

Diane Lippe
Nova Southeastern University, lippe@nova.edu

Sharan Sankar
Nova Southeastern University, ss4468@mynsu.nova.edu

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Abstract

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Keywords

360-degree videos, immersive virtual reality, quality management, instructional design, experiential learning, design-based research

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Design and Implementation of 360-Degree Video Vignettes in Immersive Virtual Reality: A Quality Management in Higher Education Case

Martha M. Snyder[1], Steven Kramer[2], Diane Lippe[3], and Sharan Sankar[4]
[1]Abraham S. Fischler College of Education and School of Criminal Justice, Nova Southeastern University, USA
[2]H. Wayne Huizenga College of Business and Entrepreneurship, Nova Southeastern University, USA
[3]Learning and Educational Center, Nova Southeastern University, USA
[4]Razor's Edge Research Program, 4+4 Dual BS/DO, Nova Southeastern University, USA

Immersive virtual reality (IVR) in higher education has gained traction as a way to engage learners in immersive and authentic learning experiences. However, there is a need for guidance on how to design and implement IVR solutions. We used a design-based research methodology to answer the following overarching research question and sub-questions: (1) How can 360-degree video vignettes presented within an IVR environment be designed and implemented to facilitate quality management competencies? (1a) How do learners experience this technology? (1b) What is the process for creating and implementing this technology? (1c) How can we best design the learning experience? We designed, developed, and formatively evaluated a use case within a master's level quality management course in a college of business and collected quantitative and qualitative data from project stakeholders. This report focuses on our qualitative data collection and analysis. Results are presented in themes and sub-themes as follows: IVR experience (sub-themes: physical discomfort, emotional sensations, and attitudes); IVR technical integration (sub-themes: resources, process flow, and stakeholders) and IVR learning integration (sub-themes: teaching and learning affordances, drawbacks, and learning design). Findings can be useful in guiding the design and implementation of IVR applications for learning in higher education.

Keywords: 360-degree videos, immersive virtual reality, quality management, instructional design, experiential learning, design-based research

Introduction

Over the last decade, the use of immersive virtual reality (IVR) as an educational tool has increased. In part, this increase is due to the affordability of head-mounted displays (HMDs) that make IVR broadly available to the general public (Makransky, et al., 2019). Increase in IVR use also reflects the changing demographics of today's college students. For example, Schwieger and Ladwig (2018) pointed out that the rising population of Millennials and Generation Z on our college campuses have been raised with technology and therefore expect their college learning experiences to include use of technology for learning.

Distinguishing between IVR, augmented reality (AR), and MR (mixed reality) helps to understand where and how this study fits. In IVR, avatars are placed within a completely virtual environment. Wearing an HMD and using a controller, the learner is fully immersed visually

and aurally in the environment. In AR, avatars are projected over a real environment, such as an avatar standing on a real floor. MR combines the capabilities of IVR and AR where there is some degree of both virtual space and reality "within the same visual display environment" (Milgram & Kishino, 1994, p. 2). The term, spatial computing, is often used to describe these three realities noting [spatial computing] is "the use of space around us as a medium to interact with technology…we describe those technology by the type of interaction we have with it, not by the object we interact with" (Agulhon, 2016, para. 1). Companies such as Magic Leap®, Microsoft®, and Oculus® have developed immersive and spatial computing solutions. For example, devices such as Magic Leap One, Microsoft HoloLens, and Meta Quest (formerly Oculus Quest) can be used in conjunction with web-based scenarios and apps to create immersive experiences in entertainment, business, and education. Our study engaged students in 360º video vignettes within an IVR environment using the Oculus Quest 2, a stand-alone, all-in-one virtual reality headset.

Literature Review

IVR for Learning

Current IVR research ranges from technical aspects such as the development of a bidirectional system designed to improve the authenticity of avatars used for professional interactions and intimate conversations (Wei et al., 2019) to social aspects such as how bias impacts interactions with virtual humans (Zipp & Craig, 2019). As IVR has become more popular in higher education, research agendas focused on design and implementation of IVR for educational purposes has increased. For example, Marks and Thomas (2022) designed a virtual and augmented reality (VAR) lab and evaluated the design, cost, adoption rates, and student experiences over a period of five semesters. They argued that in any attempt to diffuse an innovation, it is important to have a place where stakeholders can learn the technology and be supported in its implementation. The value of their study was that creating a VAR lab was worth the investment because it facilitated technology adoption broadly across the university.
With regard to learning, Makransky et al. (2019) conducted a study on the effectiveness of IVR for laboratory safety training. They used multiple assessments to measure various factors including prior knowledge, intrinsic motivation, self-efficacy, learning retention, and behavior transfer and found that the IVR environment positively influenced these factors. Similarly, Schroeder, et al. (2019) investigated the impact of learner control over instructional videos within virtual humans, finding a positive correlation between learner control and learning outcomes. In a literature review by Papanastasiou et al. (2019), promising results were reported regarding the use of IVR in higher education. Students' 21st-century skills such as creativity, communication, collaboration, and problem-solving improved in an IVR environment. The review also highlighted enhancements in student engagement, multi-sensory learning, and spatial ability. Recommendations for future research included exploring the application of IVR in classrooms and investigating learners' experiences, including content comprehension, motivation, collaboration, and potential barriers to positive learning experiences (Makransky, et al., 2019).

Learning and Instructional Design Theories and Models

There are a variety of learning and instructional design theories and models that support IVR for learning. For example, Dalgarno and Lee (2010) proposed a model of learning in 3-D virtual learning environments (VLEs) that incorporates ten distinguishing characteristics and five affordances for learning. They divided the characteristics into two categories:

representational fidelity and learner interaction. Representational fidelity includes the characteristics of realistic display of environment; smooth display of view changes and object motion; consistency of object behavior; user representation, spatial audio, and kinesthetic and tactile force feedback. Learner interaction includes the characteristics of embodied actions including view control, navigation, and object manipulation; embodied verbal and non-verbal communication; control of environment attributes and behavior; and construction of objects and scripting of object behaviors. The five learning affordances of VLEs include the following:

1. learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain.
2. experiential learning tasks that would be impractical or impossible to undertake in the real world.
3. learning tasks that lead to increased intrinsic motivation and engagement.
4. learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualization of learning.
5. tasks that lead to richer and/or more effective collaborative learning than is possible with 2-D alternatives (Dalgarno & Lee, 2010, pp. 18-22).

Fowler (2015) argued that Dalgarno and Lee's (2010) model focuses primarily on the technical affordances rather than the pedagogical affordances (i.e., a perspective that focuses on learning outcomes and objectives). Therefore, Fowler extended Dalgarno's and Lee's model to include pedagogical considerations. Using the concept of "pedagogical immersion," Fowler argued that his enhanced model emphasizes the importance of creating an "experience that "meets the needs of the intended learning outcomes (ILO)" (p. 417). Fowler's model provides more prescriptive design guidance by identifying specific learning stages (i.e., conceptualization, construction, and dialog) and describing how specific learning requirements can be specified for each. Then, these requirements can be matched to the technical learning affordances that are inherent in VLEs. In addition, Fowler purported that his model is more useful for practitioners whose goal is to design and plan activities for a learning session or course that is defined by a "set of specific learning outcomes" (p. 417).

In addition to these two models that focus specifically on VLE design, other theories such as constructivism and case-based learning are also relevant. For example, case-based learning is useful in situations where one must address ill-structured and complex problems and has been effective in bridging the theory-practice gap by presenting real-world problems and authentic situations. Video vignettes is one way to present cases in a motivating, context-specific and authentic way (Dannemann, 2018). Jonassen (1999) explained that project-based learning, problem-based learning, and case-based learning all share the same assumptions that learning is active, constructive, and authentic. Jonassen further defined how tenets from constructivist learning environments (CLEs) support the instructional design of case-based learning. Central to CLE design is the problem or learning goal, which should be interesting and ill-structured. These qualities ensure that learners have some sense of ownership of the problem and can construct their own meaning and solutions. This type of inquiry-based, student-centered, authentic, constructive, learning environment is considered as best practice for the acquisition of complex, ill-defined problems and student engagement (Tawfik, et al., 2020). These theories and models can be useful in developing guidance on how to implement IVR solutions for learning in higher education.

Quality Management Competencies

This use case focused on a quality management course; therefore, it is important to briefly define the role and competencies of a quality manager (QM). A QM is the person in an organization who is responsible for ensuring that products and services meet both internal and external stakeholder requirements, which typically include specific customer expectations, compliance-related requirements, and standards of excellence. The QM identifies quality standards and implements strategies to ensure these standards are achieved (Ingason & Jónsdóttir, 2017). While the role of the QM differs depending on the industry (e.g., healthcare, manufacturing, and consulting), there are certain competencies that are relevant across all contexts. The ASQ Quality Body of Knowledge (QBOK; American Society of Quality, 2009) uses the Quality Journey to categorize basic QM competencies into the following:

1. Pursuit of Personal Excellence
2. Pursuit of Operational Excellence
3. Pursuit of Organizational Excellence
4. Pursuit of Quality Ideal

These four categories comprise a combination of social skills (e.g., communication, emotional intelligence, persuasion/influence, and leadership skills) and technical skills (e.g., process management, measurement, use of statistical methods and quality tools, and project management). Martin et al. (2021) proposed a quality management competence framework to guide an understanding of what quality management practitioners need to know and do. They identified three competence dimensions (i.e., human, methods and process, and conceptual) and associated role responsibilities (i.e., strategic and centralized role responsibilities, strategic and local role responsibilities, operational and centralized role responsibilities, and operational and local role responsibilities).

Ingason and Jónsdóttir's (2017) conceptual model for QM competencies and Martin et al.'s (2021) competence framework align with the Quality Journey framework and provide additional guidance for those interested in developing a strong and well-balanced QM skillset.

With our use case, we aimed to determine how to facilitate the development of QM competence through IVR. Specifically, learners developed competence in planning, systems thinking, data analysis, auditing, communication, problem resolution, application of QM tools, etc., by engaging in IVR scenarios that required them to work individually and collaboratively to identify, document, and assess process steps and process flows in a retail business context.

Rationale for Study and Intended Audience

The demands of higher education institutions to find new ways to attract, engage, educate, and empower their students drive the need to find new and innovative teaching and learning solutions. As this demand grows, there will be an increased need for process and learning design guidelines to support and sustain the development and implementation of solutions focused on educating and training the new workforce (Schwieger & Ladwig, 2018). As new and emerging learning systems develop, it is important that the instructional techniques and methods that we use are grounded in existing learning and design theories (Branch & Stefaniak, 2019; Reigeluth & Carr-Chellman, 2009). Foundational standards of quality management, constructivist learning theory, case-based instructional design theory, and design and development research methods guided our IVR design case. The intended audience for our work includes practitioners and researchers in higher education who are interested in understanding what needs to be considered when developing 360-video vignettes in-house, the

process flow for implementing 360-video vignettes within an IVR environment as part of a course, and what types of frameworks and models can be used to guide the learning design.

Purpose and Research Questions

The purpose of this design-based research (DBR) was to explore the design and implementation of 360-degree video vignettes within an IVR environment in higher education. The context was a master's course in quality management that consisted of 16 students who either attended class in person or remote. Our overarching research question was: *How can 360-degree video vignettes presented within an IVR environment be used to facilitate the development of quality management competencies?* We also had three sub-questions as follows: (1a) How do learners experience this technology? (1b) What is the process for creating and implementing this technology? and)1c) How can we best design the learning experience?

Self-of-the-Researchers

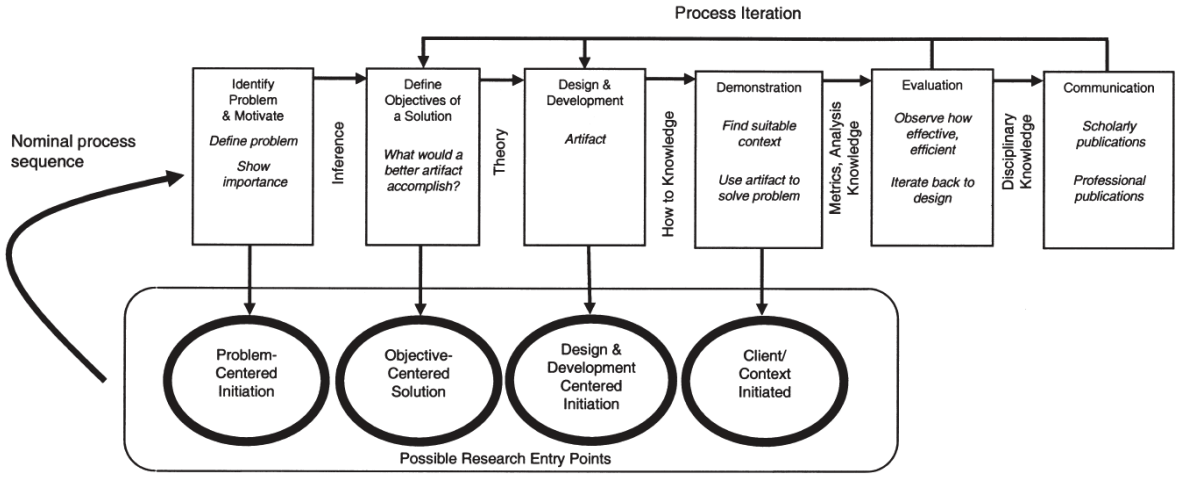
This research was a collaboration among four individuals at Nova Southeastern University who were brought together as a result of NSU's President's Faculty Research and Development (PFRDG) grant. The first author led the research project including the data collection, analysis, reporting, and dissemination of results. Her background is in project management, the design of technology-based learning designs, and qualitative research methods. The second author taught the quality management course and also created the 360-degree videos. He has 20 years of industry experience in industrial engineering, procurement, advanced manufacturing, quality management and process improvement. He served as the subject-matter expert. The third author is the executive director for the university's Learning and Educational Center. She is an experienced leader of instructional design teams, video production units, and faculty development initiatives at the university. The fourth author is an undergraduate student at the university and is also part of the university's Razor's Edge Research program. He assisted the first author in coding the interview data.

Methodology

In this paper, we present the qualitative findings of our design-based research (DBR) study. Incorporating qualitative methods was important because we sought a better understanding of the learner's behavior in a natural setting. The inductive and multilinear thinking that are characteristic of qualitative research enabled us to use the data to generate broad-based themes and move in a non-linear, iterative fashion throughout the analysis. Rather than looking at specific variables, we were able to take a more holistic approach and gain a better understanding of *how* to design and implement IVR in higher education settings. Finally, being able to play a key role in the research process enabled us to do an in-depth study and make meaning from the data (Lichtman, 2023). We designed our methodology from the design-based research and design-science literature. In the context of educational technology and technology-enhanced learning environments, in particular, Wang and Hannafin (2005) described DBR as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (p. 7). They described DBR as *pragmatic*–refining both theory and practice; *grounded* – theory-driven and conducted in real-world settings; *interactive, iterative, and flexible* – moving through an iterative cycle of analysis, design, and implementation; *integrative* – incorporating both quantitative and

qualitative data; and *contextual* – research results are aligned with the design process and setting. In DBR, the researcher plays an active role not only in the design but also the research. Hevner, et al. (2004) described design science within the discipline of information systems as a "problem-solving paradigm…" It "creates and evaluates [information technology] artifacts intended to solve identified organizational problem" (p. 77). We selected this design-based approach because our aim was to refine both theory and practice related to IVR design and implementation in a real-world setting. We wanted to explore how to design and implement 360-degree videos in an IVR environment with a focus not only on the practical implementation but also on the conceptual and theoretical underpinnings that are most useful and appropriate for IVR design in higher education. Peffers, et al. (2008) described design science as a methodology that supports the process of designing "artifacts to solve observed problems … Such artifacts may include constructs, models, methods, and instantiations" (p. 49). Peffers, et al. (2008) developed a design-science research methodology process model that we used to guide the phases of our research (Figure 1). Each of these phases are described in relation to our project.

Figure 1
DSRM Process Model from Peffers et al. (2008)



Phase 1 – Problem Identification: The problem we identified was lack of design and implementation guidance for 360-degree videos within IVR used in higher education.

Phase 2 – Defining Objectives of a Solution: Following were our objectives:

1. Design and implement an instructional module that involves graduate students using 360-degree video vignettes in IVR to apply quality management principles, tools, and techniques in order to document and assess process flows in a variety of real-world business scenarios (e.g., product assembly, quality meetings, strategy meetings).
2. Explore students' pre-conceived notions about using IVR for learning.
3. Explore students' perceptions about their experiences using IVR for learning.
4. Document the process flow for the design and implementation of 360-degree video vignettes in IVR.

Phase 3 – Design and Development of the Artifact: An instructional module (case) that focuses on the application of quality management principles, tools, and techniques in a retail setting was developed for a graduate-level quality management course. The second

author, who is a subject-matter expert and the professor for the course created and produced the 360-degree video vignettes for IVR.

Phase 4 – Demonstration – Using the Artifact to Solve the Problem: The second author implemented the instructional module in Fall 2021 as part of his graduate quality management course. This was a cross-listed campus-based and synchronous online course where students could participate by coming to class in-person or attending the class remotely by logging into Zoom, a web-conferencing software. Canvas, the university's learning management system (LMS) was used to facilitate the sharing of course documents, assignments, online discussions, and grades. The instructional module incorporated low-fidelity (e.g., text-based and online pre- and post-work, in-class practice, etc.) and high-fidelity (i.e., 360-degree video vignettes in IVR). During the implementation, the first author observed the instantiation of the case in vivo to document relevant design guidelines. She also maintained a research journal of design decisions ranging from technical specifications to instructional method choices.

Phase 5 – Evaluation: Qualitative and quantitative data were collected and analyzed.

Phase 6 – Communication: We have shared our results through various conferences and workshops and hope to publish our work in a scholarly journal as suggested by Peffers et al. (2008).

Data Collection

The data collection process was emergent and flexible. The following data collection methods were used:

1. **Demographic & VR Use Pre-Screening Questionnaire:** This questionnaire (Appendix A) was used to pre-screen study participants. We collected basic demographic information such as gender, age, and ethnicity and asked questions relating to the participants' previous experience and interest using IVR. Participants were also assessed on their potential for simulator sickness using questions from Kennedy et al.'s (1993) Simulator Sickness Questionnaire.
2. **Observations and Reflexive Journal:** During the implementation of the case, we observed participants engaging in IVR to inform our design decisions and capture participants' surface reactions. The first author maintained a reflexive journal of design decisions that were made and notes about strengths and weakness of the design.
3. **Individual Semi-Structured Interviews:** Individual semi-structured interviews were conducted with two students (one local and one remote), the course instructor, who is also the subject-matter expert and developer of the 360-degree videos, and the vendor who provided the application used to connect participants in the virtual space. These interviews were designed to explore in detail our research questions. Questions addressed how participants felt about learning in IVR, whether the activities and IVR interactions were appealing and relevant, what changes they would make to the case, and whether they felt the learning objectives were obtained. Interview guides (Appendix B) were developed for all three types of interviews (i.e., student, instructor, vendor). A verbal consent form (Appendix C) was used to gain consent before each interview.
4. **IVR Perceptions Questionnaire:** The IVR Perceptions Questionnaire (Appendix D) assessed the student-participant's perceptions about the usefulness, ease of use, and enjoyment of their IVR experience and their

> intention to use IVR in the future. Tokel and Veysi's (2015) scales for these constructs were used. Wording was changed from "virtual worlds" to "immersive virtual reality" to address the objectives of this study. Open-ended questions for each construct were added to capture more in-depth information about participants' perceptions about these constructs.

Prior to participant recruitment and data collection, approval of the research procedures was granted by NSU's Institutional Review Board (IRB) (Appendix E). Codes were assigned to audio recordings prior to transcriptions and pseudonyms were used in the reporting of exemplar quotes to protect the participants' identities.

Sample Size and Description

The initial sample included all 16 students enrolled in a graduate quality management course at Nova Southeastern University (NSU). All 16 students completed the *IVR Demographic and Pre-screening Questionnaire* at the beginning of the semester. Six were male and ten were female. Students' ages ranged between 24-50 with one over 50. Twenty-five percent (n=4) of the students identified as White; 25% (n=4) identified as Black or African American; 31% (n=5) identified as Hispanic, Latino, or Spanish Origin; 6% (n=1) identified as Asian and 12% (2) identified as Middle Eastern or North African.

Eight students opted in to using Oculus headsets to watch the 360-degree video vignettes. Six of those eight students completed the *Immersive Virtual Reality Perceptions Questionnaire* following the course. Two students opted in to semi-structured follow up interviews. Quality Management is a required course for the Process Improvement concentration of the MBA and is an elective course for other graduate students in the MBA program. Students at NSU and particularly in the MBA program have work experience and are generally tech-savvy. They are also familiar with interfacing though the computer in classrooms. To avoid coercion, the course professor was not involved in interviewing the participants or analyzing the interview data. In addition, interviews were conducted after grades for the term were posted.

In addition to the two students, interviews were also conducted with the course instructor and the vendor who supported the project by providing the application that enabled participants (both in class and online) to meet in an interactive space at the same time. These additional interviews enabled the first author to capture design decisions and technical specifications.

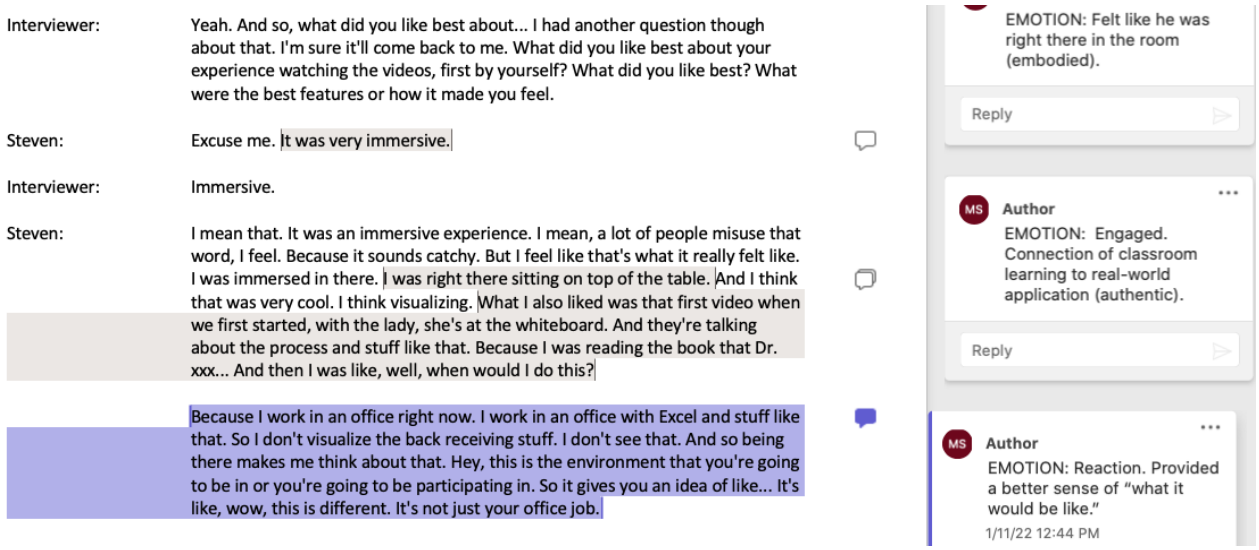
Data Analysis

Descriptive statistics were used to analyze the quantitative data from the questionnaires (Gay, et al., 2009). For brevity, these quantitative results are not reported here. For reference, a summary of the questionnaire data can be found in Appendices F and G. Regarding the qualitative data, a conventional approach to content analysis was used to analyze the qualitative data (Hsieh & Shannon, 2005). Content analysis is a technique that is used broadly in qualitative research to analyze and interpret text data. Content analysis, as opposed to other methods such as grounded theory and phenomenology, are preferred in the early stages of theory and model building as it represents a more descriptive rather than interpretive picture of the phenomenon (Hsieh & Shannon, 2005; Sandelowski, 2000). The text data that we analyzed included data from the open-ended questions in the questionnaires, and transcribed interview data. The goal was to generate themes based on the participants' unique perspectives, grounded in the data, about participating in the IVR video vignettes. Using this type of systematic

classification process for coding and identifying themes and patterns, helped us organize the data. These data coupled with our observation and journal notes helped us to answer the research questions.

The first and fourth authors analyzed the interview transcripts. The steps we implemented in the content analysis included first immersing ourselves in the data by "reading all data repeatedly to achieve immersion and obtain a sense of the whole as one would read a novel" (Hsieh & Shannon, 2005, p. 1279). Second, we read the data again line by line with attention to highlighting exact words that represent key concepts. Third, we took notes of "first impressions, thoughts, and initial analysis" (p. 1279). This process continued until we were able to identify labels for a set of codes that represented key thoughts. The data representing each of the codes were analyzed again. During this process, some codes were combined while others were divided into subcategories. Figure 2 shows an example of the coding process using Microsoft Word's Review tool. The name, Steven, used in this example is a pseudonym.

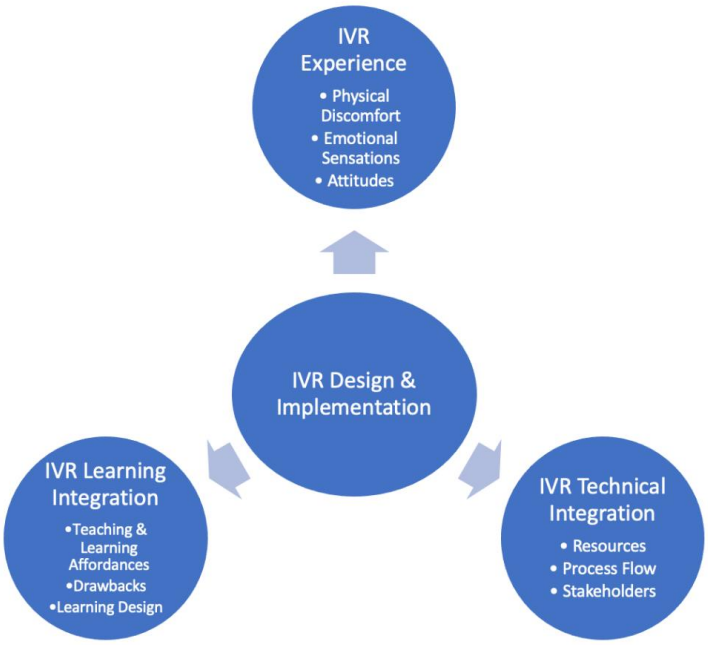
Figure 2
Example of Coding Process



Results

We organized the codes into three overarching themes: IVR Experience, IVR Technical Integration, and IVR Learning Integration (See Figure 3). Each of these themes include three sub-themes. Following is a description of each theme and its respective sub-themes. Exemplar quotes from interview participants (i.e., students and VR technical and subject-matter experts) are provided where they capture the essence of the theme and add value to the description.

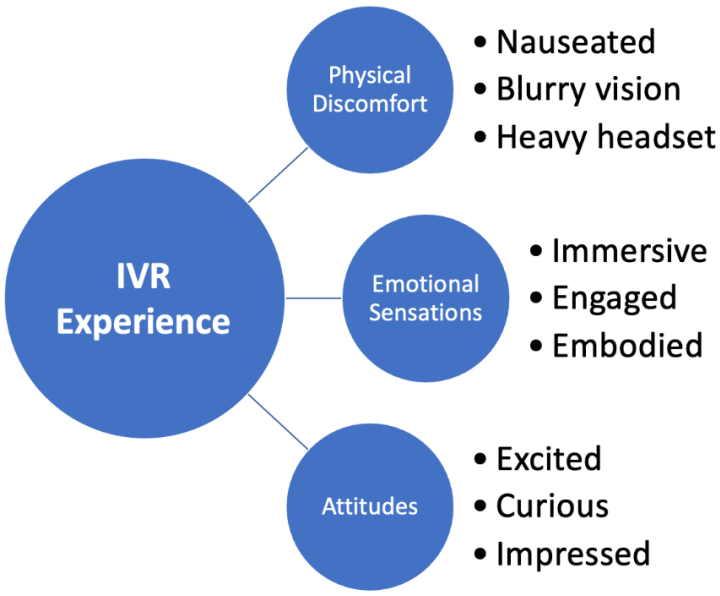
Figure 3
Themes and Sub-Themes



Theme 1: IVR Experience

IVR experience relates to the actual IVR event and how a person felt during that event. The three sub-themes include: physical discomfort, emotional sensations, and attitudes toward IVR. Figure 4 illustrates this theme and its sub-themes.

Figure 4
Theme 1: IVR Experience and Sub-Themes



One participant described their *physical discomfort* as follows: "The headset was a bit bulky and I started to get a headache after wearing it for a while. I am not sure if it was the weight on my head or my eyes adjusting to the screen." Participants who used HMDs to watch the 360-degree videos experienced some minor physical discomfort. For example, participants noted feeling somewhat nauseated at first, but that sensation subsided. Others expressed fatigue wearing the HMD for long periods of time, while others noted blurred vision, especially when the HMD was not in the correct position.

Participants expressed a variety of *emotional sensations.* One participant described their feeling of immersion as follows:

> "It was an immersive experience. I mean, a lot of people misuse that word, I feel. Because it sounds catchy. But I feel like that's what it really felt like. I was immersed in there. I was sitting right at the table."

Emotional sensations refer to the way participants experienced IVR and the affective words and phrases they used to describe that experience. For example, a word that was used frequently was *immersive*. Participants felt like they were "right in the room" with the people in the video. They described their experience as engaging because they felt like they were actually a part of the video scenario.

A feeling of embodiment was another emotional sensation as described by another participant:

> "I feel like if you're just watching a video or when you're going through this room that you can only see what's in front of you. And there's also everything else going on in that room. And I feel like when you're in the meeting, being in the room, you have a better feel for why things are happening."

When participants watched the videos, they noted that their physical self was transformed into a virtual being who was authentically participating in the scenario (i.e., as a company team member, an observer, etc.).

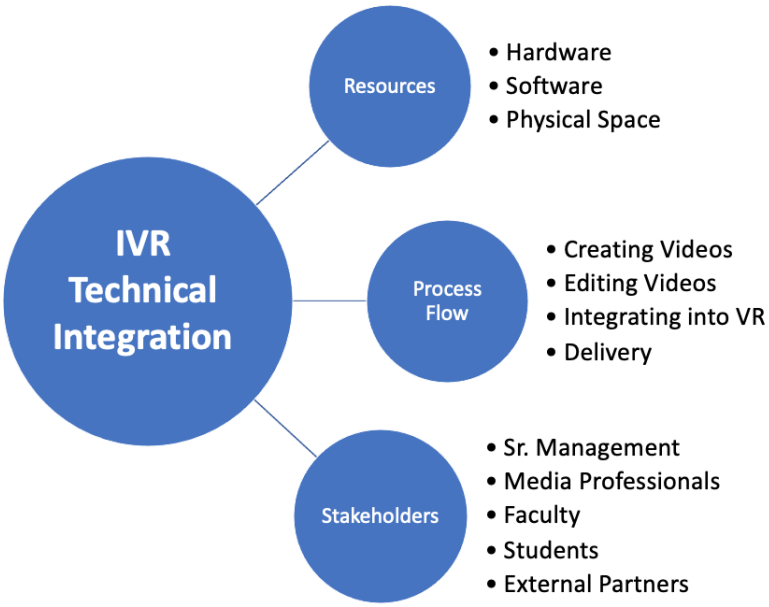
One participant described their *attitude* as follows: "I was excited to use the device anyway, so I'm one of those guys. I'm like, 'I'm just going in headfirst.'"

Participants described their IVR experience through *attitudinal expression*, which overall, was positive. Participants expressed excitement about using IVR for learning. They were curious about how IVR might be used to enhance their learning of the course content and they were impressed by the learning affordances that IVR provided.

Theme 2: IVR Technical Integration

IVR technical integration refers to how IVR was designed and implemented from a technical perspective. Three sub-themes associated with IVR technical integration include resources, process flow and stakeholders. Figure 5 illustrates this theme and its sub-themes.

Figure 5
Theme 2: IVR Technical Integration and Sub-Themes



Resources pertain to the hardware, software, and physical space required to design and implement IVR. As described by one of the VR experts who was interviewed,

> "All of the equipment together can fit in a small briefcase, which makes it easy to transport and set up. Everything including the camera, mount, and audio recorder are very light – you can compare it to a jug of milk."

The hardware that was used to create the videos included an 8K video camera that can record 360-video. A Kandao QooCam 8K Full View Camera Full HDR was used to record the video vignettes. High resolution was necessary to capture the details of the environment. For example, in the quality management meeting, it was important that participants were able to "read the writing on the flipcharts that were posted on the walls of the room."

An ambisonic audio recorder (1-Zoom H3-VR 360 Audio Recorder), which has spatial capability (i.e., ability to capture audio from left to right, front to back, and up and down) to match the quality of the video was also used. Lavalier microphones were also worn by select people (e.g., team leader, quality manager, etc.) who participated in each video vignette. Finally, a drop ceiling face down camera mount that attached to the QooCam was also used so that the video capture was centered in the room and out of the way.

The Oculus Quest 1, a wire-free head mounted display (HMD) was used to play the videos. Regarding software, The Glimpse Group provided the server space and an application called Chimera was used to house the virtual environment within which the videos were used. In addition, Chimera enabled the embedding of a smartboard, which contained basic audio controls and job aids that participants could refer to during the video (See Figure 6). It also enabled the students and the instructor to meet in a shared VR space (i.e., collaborative VR), and enabled the instructor to start and stop the video as needed. As described by one of the VR experts, this enabled the instructor to be like a curator who can point things out to the students while they are watching them. Adobe Creative Cloud Premier was used to edit the videos.

Figure 6
Quality Meeting Video Vignette with Smartboard with Job Aid Overlay

The process flow can be summed up by the following comment made by one participant as, "I would like to see it become more streamlined."

Process flow refers to the phases associated with creating and editing 360-degree videos, integrating the videos into the virtual reality space, and delivery of the videos. Issues related to creating the videos as described by the two VR expert interviewees included the preference to have someone who is not only familiar with the content but also has sufficient technical expertise to record the videos. Video releases were given to all the people in the video beforehand. If someone did not sign a release, their image was redacted from the video during the editing process. Adobe Premier Pro was used to edit the videos. With this tool, one is able to synchronize the audio with the video by following the spikes in the audio. In this instance, the editor suppressed the audio from the camera and instead used the ambisonic audio, which was higher quality. The output of the videos were MP4. Specifics including bit rate, sampling frequency, data richness, etc. were also available from the vendor (Glimpse Group) during the editing process.

Integrating into VR is the process that was used to load the videos into the VR environment. The 360-degree video vignettes were stored on a server provided by The Glimpse Group. Glimpse uses the Chimera app to access the 360-degree videos on their server. The students were provided the Chimera app so they could access the videos. The instructor was provided with a Chimera administrative access app to control the video presentations. The Chimera app was also installed on each Oculus headset. An equivalent desktop app was made available to students who did not access the videos using the Oculus.

Delivery pertains to the process whereby the students acquired the HMDs and accessed the videos. During class, the instructor physically handed out the HMDs to the students. They were allowed to take them home and practice using them. One student who participated in the study took the course remotely, so the HMD was mailed to them along with a return mailer to mail back the HMD at the end of the semester. A noted improvement would be to have a formal equipment check-in and check-out process as well as a formal HMD sanitation process. As mentioned by one of the VR experts, "We did not have a check-in/check-out process nor did

we have any agreement with the student about what would happen if they broke or damaged the equipment. This was concerning."

Finally, *stakeholders* refers to the people who have an interest and play an active role in supporting the integration of 360-degree videos into higher education courses. Stakeholders discussed during the interviews included senior management, media professionals, faculty, students, and external partners. Regarding senior management, the VR expert interviewees emphasized how senior management commitment to IVR for learning is critical. In this instance, the Dean of the college championed the effort and was supportive both financially (i.e., to acquire necessary hardware, software, and server space) and academically (i.e., supportive of faculty's efforts to integrate 360-videos into his course).

To implement 360-degree videos in IVR requires the support of media professionals. These professionals are needed throughout the implementation process from the recording, to editing, to delivery. As noted by one interviewee, "Someone from the media department who is familiar with the Adobe Suite. There is editing, stitching, and also some art, so other departments might be helpful."

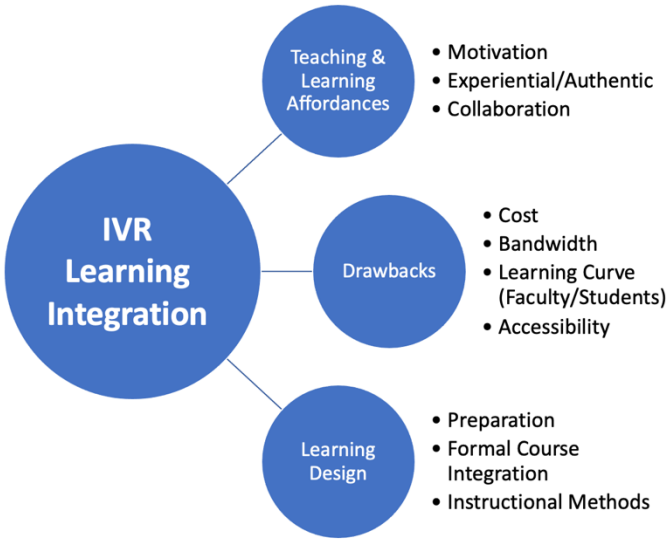
There must be faculty interest and the right kind of faculty to implement IVR. As suggested by one interviewee, "You need the right kind of faculty member to work on these types of projects – someone who is interested in working on the bleeding edge."

Finally, students who are open to learning in new ways can help diffuse IVR technology throughout the institution. Some students embrace the technology while others prefer to learn in a more traditional mode. Having options is important. In this case, for those students who did not want to use the HMDs to view the videos, they could watch the videos and participate using their computers.

Theme 3: IVR Learning Integration

IVR learning integration refers to aspects related to how IVR can be used to support teaching and learning. IVR learning integration includes three sub-themes: teaching and learning affordances, drawbacks, and learning design. Figure 7 illustrates this theme and its sub-themes.

Figure 7
Theme 3: IVR Learning Integration and Sub-Themes



Teaching and learning affordances refer to the aspects of the technology that enable ways of teaching and learning. For example, just being in the virtual environment motivated the students and the professor to engage in experiential and authentic teaching and learning. Students commented that [participating in IVR] "made the content more interesting." They also noted that the IVR "blocks distractions, because you is totally immersed in the environment." The professor expressed an intrinsic motivation to provide his students with a way to connect theory to practice. When discussing the affordance of the 360-degree video vignettes he noted,

> "It doesn't matter what background the student has, I want them to see operational issues in healthcare, financial services, manufacturing–as many different contexts as possible so they can see the similarities and differences. This [exposure] will enable students to become more capable of handling it. Ninety percent of the process for identifying waste is the same if you are doing a waste analysis, administrative waste…waste is waste."

There was one opportunity when the professor met with the students at the same time and watched the videos together. One student who participated remotely noted that they felt more like they were "actually in class" in the collaborative IVR space. Having a discussion with the professor in IVR along with watching the video vignette made the content "easier to understand."

One student interviewee noted that the cost of the HMD might be a barrier as well as the accessibility of the HMDs stating the following: "If headsets were furnished by the institution, I think it would be good because I don't know how many people can necessarily afford the Oculus."

In addition, not all students have sufficient Internet access and bandwidth to support playing the videos in IVR. The experts who were interviewed noted that there is a learning curve for both faculty and students and sufficient time to learn how to use the equipment and navigate in the IVR space is important. Finally, issues relating to accessibility were noted as not all students are able to use the HMD, such as persons who experience physical discomfort, who wear glasses, and who have physical or mental disabilities. These examples represent *drawbacks* or aspects of the IVR experience that might deter people from using IVR for learning.

Learning design pertains to the how to design a learning experience that uses 360-degree video vignettes in IVR. The student interviewees noted that they felt there could have been more structure around how the videos were introduced and used to support the course's learning objectives. This case was designed as a pilot test and therefore, the vignettes were not fully embedded as part of the course design. The vignettes were intended to support the course learning outcomes but watching them was not a requirement for the course. Figure 8 shows the course learning map, which indicates which video vignettes support specific course content.

Figure 8
Course Learning Map

9/13	View Session 4 videos: Operationalizing Quality, Work as a Process, Process Flows, Operating Systems Week 4 prep quiz (20 min) due by Week 4 class start	show a movie (The Goal). The movie will NOT be recorded, but the balance of the class session will In-class discussion (W4)	Week 4 (W4) Discussion Board	midterm: case analysis through Measure part of rubric (only)	Work as a process	Chair assembly

The student interviewees also suggested that tutorials on how to use the HMDs and the controllers and participate in the video vignettes would be helpful. They also suggested integrating the video vignettes into the course as a formal assignment with points towards their grade. Students felt that this type of integration would alleviate some of the stress of watching the videos since they were voluntary and perceived as an add-on. Students also expressed appreciation and a desire to have more collaborative meetings with their fellow classmates and the professor. They noted activities such as role plays and guided discussions as beneficial.

Discussion

These findings can help us design and implement IVR learning experiences within the context of higher education. First, analysis of the IVR experience can help us plan for learners who might not feel comfortable using HMDs. For example, in our case we could deliver the 360-degree videos through a web-based application where learners are able to interact by using the computer mouse to pan around the video. We can also leverage the excitement and curiosity that comes with learning through IVR as a way to engage learners in meaningful and authentic ways. Understanding the emotional sensations that result from the IVR experience provides insight into what types of scenarios make the most sense to present using 360-degree video and IVR, as well as positioning of the IVR experience within the course timeline. With regard to 360-degree scenario development, Feurstein (2018) suggested creating generic, activity-oriented learning scenarios that could be used by a variety of learner audiences. On the other hand, regarding IVR more broadly, Won et al. (2023) found that even with the same learning topics and demographics, IVR learning experiences can be vastly different. They recommended choosing design features carefully and base them on "educational objectives, priorities, and environmental constraints" (p. 15).

Second, with regard to IVR technical integration, this study enabled us to document the workflow and identify potential challenges. Assessing what resources (both physical and human) are available to facilitate the integration of IVR into an institution's workflow would be a good first step in planning for IVR implementation and adoption. Documenting the workflow process from identifying potential scenarios, collaborating with external partners, recording, editing, integrating videos into VR, cataloging and checking out HMDs, to cleaning and updating application software, can create a more efficient process when implementing on a larger (e.g., institution-wide) scale and facilitate the innovation uptake. These findings cohere

with Feurstein (2018) who reported in detail workflow steps for creating 360-degree video content for higher education. He recommended a focus on technology integration, saying it was critical to gain adoption of 360-degree video technology at scale.

Finally, exploring and identifying the affordance and drawbacks of the technology and the learning experience as expressed by the learners themselves, helps us to identify the gaps in learning design and how to better integrate IVR into the course. For example, participants expressed the need for an orientation to the use of the HMDs and the IVR environment. Therefore, a tutorial on how to use the controls and navigate the environment along with a pre-brief of the scenario is recommended. There are also implications for faculty training on how to effectively integrate IVR into their classrooms. The development of frameworks and guidelines to support faculty both in the learning design and course integration are needed to ensure a quality experience for both educators and learners alike. Finally, there are issues relating to accessibility that need to be addressed. Teófilo et al.'s (2019) work focuses on accessibility systems for virtual reality. Through a usability study, they identified needed accessibility features in the virtual environment. They found that when virtual reality systems are designed with accessibility features, such as captioning systems and teleoperation through an HMD, usage by persons with disabilities (e.g., vision/hearing loss and mobility challenges) improved. In addition to the challenges persons with physical disabilities experience, there are also challenges faced by persons with intellectual and developmental disabilities such as manipulating the controller, fragility of the equipment (easily broken), and sensory sensitivities (i.e., the IVR environment is too intense) (Oakes, 2022). It will be important to not only consider learning design for IVR but also accessibility design to meet the needs of *all* learners. Conducting usability studies to identify accessibility gaps for both physical and intellectual/developmental disabilities is in its early stages and should continue.

While not explicitly mentioned or discussed in the questionnaire and interview data, the observations and reflexive journal notes provided insight into learning theories and instructional design theories that best support how teaching and learning take place in the context of 360-degree video vignettes presented in IVR. Learning theories such as Kolb's (1984) Experiential Learning Theory, Social Constructivism (Vygotsky, 1978), and Situated Learning Theory (Lave & Wenger, 1991) can underpin how learning takes place in IVR. These theories combined with prescriptive instructional design theories and models can provide more precise guidelines regarding how best to design learning given particular situations. For example, the four modes of Kolb's learning cycle, namely concreate experience, reflection, abstract conceptualization, and active experimentation could guide a more robust IVR experience. For example, Fromm et al. (2021) used a series of design thinking workshops to develop three low-fidelity virtual reality prototypes that encompass the four modes. That is, they used the four modes to guide and categorize design elements for IVR. This work could be extended by developing specific instructional design guidelines for each of the four modes. Prescriptive strategies and activities for facilitating reflection of an IVR experience, for example, would be helpful. In addition, principles from simulation design such as pre-briefs, facilitation, and debriefs would be useful structures. The International Nursing Association for Clinical Simulation (INACSL) has outlined best practices for simulation design that would be a useful framework (INACSL Standards Committee, 2016). Finally, principles from the field of computer-supported collaborative learning (CSCL) would be useful in guiding IVR experiences that include learning collaboratively within the IVR environment. For example, Punako (2018) used formative research to develop an instructional-design theory for the development of the mixed reality museum co-visit theory, which guides the design of CSCL using augmented and virtual reality in museum education. Punako's work could be extended by applying his theory to the IVR environment.

Regarding the generalization of these results, we suggest that the three overarching themes and related sub-themes would be applicable and general enough to guide IVR integration across disciplines; however, the fact that this was a single use case in a college of business is a limitation. Use cases in other disciplines such as healthcare and education would be beneficial to determine whether other themes emerge. Also, we were limited by our research timeframe. If we had more time, we would have liked to have conducted interviews with more stakeholders. In particular, viewpoints from higher education administration would have provided insight into potential barriers and opportunities for acquiring technology equipment and infrastructure that would be necessary for institutional adoption.

This study has implications for both practitioners and researchers. For those who may be charged with implementing IVR within their own institutions, the themes herein can provide an initial framework. For example, through our description of the use case combined with the results of our data analysis, practitioners can develop an understanding of what to expect and how get started with an IVR project plan. For researchers, our recommendations for worthwhile investigations include studies that focus on whether and to what extent course learning outcomes are achieved through the use of 360-degree video IVR learning outcomes; whether there are differences in learning outcomes between learners who experience 360-degree video vignettes using a web-based application versus an HMD; and how specific instructional design theories and learning theories such as those we described, can be used to most effectively and efficiently guide the design of 360-degree video IVR experiences.

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Appendix A: Demographic and Pre-Screening Questionnaire

Immersive Virtual Reality Demographic & Pre-Screening Questionnaire

Introduction and Survey Instructions

You are receiving this survey because you are a student in PIM5450: Quality Management and have agreed to participate in a research study about how virtual reality (VR) can be used to facilitate learning. The purpose of this survey is to collect basic demographic information and get an idea about any past experiences with VR and related technologies. It should take no longer than 7-10 minutes to answer the questions.

Completing the survey implies your informed consent to participating in this research study. No identifying information will be included in the research report. This research study is monitored by Nova Southeastern University IRB protocol number 2021-236 for research compliance.

If you have any questions or concerns, you may contact Marti M. Snyder, Ph.D. (smithmt@nova.edu) or 954-262-2074, Principal Investigator (PI), Abraham S. Fischler College of Education and School of Criminal Justice, or Steven Kramer, Ph.D. (sk863@nova.edu) or (954) 288-4782, Co-PI, H. Wayne Huizenga College of Business and Entrepreneurship, Nova Southeastern University.

Demographics

1. What is your gender?

   Male

   Female

   Other

   Prefer not to answer

2. What is your age?

   Under 18

   18-23

   24-29

   30-34

   35-40

   50 or over

   Prefer not to answer

3. What category best describes you?

White

Black or African-American

Hispanic, Latino, or Spanish Origin

American Indian or Alaskan Native

Asian

Native Hawaiian or Other Pacific Islander

Middle Eastern or North African

Some other race, ethnicity, or origin

Prefer not to answer

Experience with Virtual Reality

4. Have you ever participated in a computer-based simulation, video game, or virtual reality (either wearing or not wearing a VR headset) that placed you, as the player, within a virtual world/space?

   Note: A virtual world/space is a computer-simulated environment that may be populated by one or many users who can create personal avatars. In a virtual world/space, one can participate in activities and explore the world/space independently or together.

   Yes

   No

5. If you answered yes to the previous question, please indicate how much each symptom below affected you as you played a simulation, video game, or virtual reality that placed you within a virtual world. Please select none, slight, moderate, or severe for each symptom.

   * Vertigo feels like you or your surroundings are moving when they are not. You may experience feelings of falling, tilting, spinning, or otherwise feeling off-balance. ** Stomach awareness means that you feel a little discomfort in your stomach but not as severe as feeling nauseated.

Symptom	None	Slight	Moderate	Severe
Fatigue				
Headache				
Feeling nervous or anxious				
Eye Strain				
Difficulty focusing				
Salivation increase				
Sweating				
Nausea				
Difficulty concentrating				
Fullness of the head				
Blurred vision				
Dizziness with eyes open				
Dizziness with eyes closed				
Vertigo				
Burping				
Stomach awareness				

6. If you answered anything but "None" for the symptoms in question 5, are these symptoms related to being in a virtual world while wearing a VR headset (e.g., Oculus Quest, Vive, etc.) or without wearing a VR headset?

   Wearing a VR headset

   Not wearing a VR headset

7. On a scale of 1 to 5 with 1 being not at all experienced and 5 being very experienced, how would you rate your level of experience using computer games (e.g., computer-based games, simulations, virtual reality, augmented reality, mixed reality)?

   Not at all experienced | Not very experienced | Somewhat experienced | Experienced | Very experienced | N/A

8. If you have experience using computer games, briefly describe what games you have played and how you access the games (e.g., computer, gaming console, gaming headset, VR headset).

9. On a scale of 1 to 5 with 1 being not experienced and 5 being very experienced, how would you rate your level of experience using VR headsets?
   Note: Examples of VR headsets include but are not limited to HTC Vive, Oculus Quest, Oculus Rift, Sony PlayStation, HP Reverb, Valve Index, etc.

Not at all experienced	Not very experienced	Somewhat experienced	Experienced	Very experienced	N/A

10. If you've had previous experience (prior to this course) using VR headsets, briefly describe how you have used them (e.g., for gaming at home, in other classes, etc.).
    Note: Examples of VR headsets include but are not limited to HTC Vive, Oculus Quest, Oculus Rift, Sony PlayStation, HP Reverb, etc.

11. On a scale of 1 to 5, where 1=very negative and 5=very positive, what is your overall opinion of VR technology?

Very negative	Negative	Neutral	Positive	Very positive	N/A

12. Do you anticipate having any difficulties using a VR headset?

    Yes

    Maybe

    No

13. What additional comments or questions do you have? Feel free to clarify or elaborate on any of your responses here.

14. If you have been selected as a pilot tester of this survey, please take a moment to jot down your thoughts here about the following:
    Were there any questions that were confusing? If so, which ones and why?
    Are there any questions you would suggest modifying, deleting, adding? If so, please note them.
    What other suggestions do you have for improving this survey?
    What additional questions do you have?

15. We are seeking volunteers who are willing to use VR headsets to access about six unique video scenarios in a synchronous mode with the rest of the class (who will access the same videos through a regular monitor in a shared gaming environment) throughout the term. These are not the same videos that are already posted in Canvas for the pre-work. We will

have a system in place for you to check out the headsets at the beginning of the term and return them at the end of the term.
Would you be willing to use an Oculus VR headset to access these videos (vs. accessing them through the computer)? If so, please provide your name below.

Appendix B: Interview Guides (Students, Course Instructor, Vendor)

Interview Guide-Students

Name participant: Date/Time:

Assigned code or pseudonym:

[Script begins.]

Introduction

Hello, my name is [name of IRB-approved investigator]. I am glad you've agreed to be interviewed and I thank you in advance for your time. I want to explain how this will work. We'll do about a 30-45-minute interview that will be recorded and transcribed. Once transcribed, I will send you the transcription for your review to make sure that everything to captured accurately.

There are two parts of the interview.

In the first part, I'll ask some general questions about your previous experience using virtual reality (in a variety of forms – computer, gaming console, headset).

The second part of the interview will focus on clarifying some of the responses that participants provided in the questionnaire about their VR experience in the course, usefulness of the VR vignettes, etc.

Before we get started, do you have any questions about the verbal consent or the interview questions? *(Answer questions. If participants did not get a chance to review the questions, tell them that it's okay given this is a semi-structured interview and you will have specific questions based on their survey responses.).*

Okay, let's get started.

Interview Questions

The following questions are provided as a guide. Additional questions might come to mind during the interview process. At the same time, some of these questions might not be relevant in a given situation.

Part 1: Experience with Virtual Reality

1. Tell me about your experience using VR. Have you used it before?
    a. If so, did you experience VR on the computer (Xbox, Wii), using a headset (Oculus, PlayStation, HTC Vive), other?
    b. If so, how did you use VR (for gaming, immersive/3D videos/movies, other)?
    c. If so, have you ever experienced any ill-effects/discomfort when using VR such as fatigue, vertigo, anxious or nervous feelings, nausea, dizziness, eye strain, etc.?

   d. If yes, how often do you use VR (daily, weekly, monthly)?
2. Did you experience any difficulties using the Oculus for this course?
3. Did you feel that you were provided adequate instruction on how to use the Oculus for this course? If so, what was the most important information? If not, what additional information would you liked to have known?

Part 2: Perceptions and Use of Virtual Reality in Fall 2021 Quality Management Course

1. Which City Furniture vignettes did you watch in VR (strategic planning process, quality department meeting, chair assembly team meeting, chair assembly-wooden or metal, cross-functional weekly meeting, customer care department meeting).
2. What did you like best about your experience watching these vignettes?
3. What did you like least about your experience watching these vignettes?

What would you change about your experience watching the vignettes?

Support of Learning and Improvement of QM Skills

1. Most of the respondents to the survey felt the experience was useful in supporting their learning. Do you think the same level of usefulness could be achieved without using the headset (i.e., watching 360-degree video on the computer)?
2. We received mixed responses when it came to the affordances of VR in helping students improve their quality management skills. What are your thoughts?

Usefulness of VR

1. There were some comments about the value of having more interactive meetings within the VR environment. What are your thoughts about this?
2. What are your thoughts about requiring students to watch the videos (either on a headset or on the computer) instead of making them voluntary? That is, making these activities part of the course assignments?

Ease of Use

1. There were mixed reviews about learning how to use the VR headset. What are your thoughts about this? What do you think would make using the VR headset easier to use?
2. Most respondents of the survey found using immersive VR easy to use. What are your thoughts? How could we make it easier for students to use the Oculus?
3. Did using the Oculus help you be less distracted than if you were to watch the videos on the computer (for example)?

Enjoyment

1. Most respondents felt that using immersive VR should be enjoyable but reported mixed reviews on their actual level of enjoyment. Why do you think this happened (e.g., sound quality, video quality, features related to how comfortable the headset is)?

Intention to Use VR for Learning in the Future

1. What are your thoughts about how we might use VR for other courses (e.g., holding class meetings in VR, other topics, applications)?
2. What are the potential drawbacks to using VR in courses?

Thank you for taking time to complete this interview. Your responses will help us improve the way we integrate VR in higher education and we sincerely appreciate you for volunteering for this very important research.

Interview Guide – Course Instructor

1. What motivated you to initiate this type of project with your students?

2. What are some of the benefits of implementing this type of learning experience for students? That is, what is the value of iVR that you see?

3. What are the barriers to implementing this type of application of iVR in higher education?

4. If someone were to copy what you did, what equipment and skillset do they need?

5. Let's start with what they need to know how to do.

6. Okay, now, what is the equipment they would need?

7. If we had a dedicated support team who could help with the technical aspects of the iVR experience, what would that team look like? What support is needed (e.g., recording the videos, redacting, loading on to SharkMedia, etc.)?

8. How did you get senior management support? What was the "hook?"

9. Thinking about how you integrated the vignettes into your class, what did you do in terms of how you integrated it. Can you describe it?

10. If you had to do it again, what would you have done differently?

11. What are your thoughts about how you might be able to measure learning outcomes as a result of the vignettes?

12. What factors influence user acceptance if iVR in this context?

13. How might you recommend applying this type of iVR implementation across campus and in other disciplines?

14. What additional thoughts, ideas, or suggestions do you have about the use of iVR in higher education that we have not discussed thus far?

Interview Guide – Vendor

1. What is your current position at Glimpse Group/Pagoni?

2. Can you please describe how you (your company) supported our recent project?

3. What other types of VR projects/applications are you working on within higher education? What types of support do you typically provide to clients in higher education? Can you provide some examples?

4. Based on your experience working on VR projects within higher education, where do you see the most benefit/value? What should we be looking at in terms of VR applications?

5. What competencies do you think faculty need to integrate VR into their classrooms?

6. What type of support do you think is needed from other stakeholders within the university (e.g., senior management, IT, students, library staff, etc.)?

7. What are your thoughts, in general, about how VR is being used in higher education? How far off on the horizon is it before it becomes more ubiquitous (e.g., 3-year, 5-year, 10-year horizon)?

8. Who are the major players in VR (e.g., Meta, MagicLeap, Snap, NVIDIA, Google, Roblox, etc.)? https://www.fastcompany.com/90715451/most-innovative-companies-augmented-reality-virtual-reality-2022

9. What additional thoughts, ideas, or suggestions do you have about the use of VR in higher education that we have not discussed thus far?

Appendix C: Verbal Consent Form for Participation in the Research Study

Verbal Consent Form for Participation in the Research Study Entitled Formative Research on Instructional Design Theory for Immersive VR in Higher Education

Funding Source: Nova Southeastern University President's Faculty Research and Development Grant (PFRDG)
IRB Protocol #: 2021-236
Principal Investigator:
Martha M. Snyder, Ph.D.
Nova Southeastern University
Abraham S. Fischler College of Education and School of Criminal Justice
Carl DeSantis Building, Fourth Floor
3301 College Avenue
Fort Lauderdale, Florida 33314-7796
(954) 262-2074
Co-Principal Investigator:
Steven Kramer, Ph.D.
Nova Southeastern University
H. Wayne Huizenga College of Business and Entrepreneurship
Carl DeSantis Building, Fifth Floor
3301 College Avenue
Fort Lauderdale, Florida 33314-7796
(954) 288-4782
For questions/concerns about your research rights, contact: Human Research Oversight Board (IRB), Nova Southeastern University, (954) 262-5369/Toll Free: (866) 499-0790

Name of potential participant: _____
Referral source: _____
[Script begins.]
Hello, my name is [name of IRB-approved investigator] and I am a researcher working on a study called Formative Research on Instructional Design Theory for Immersive VR. The principal investigator is Dr. Martha Snyder and the co-principal investigator is Dr. Steven Kramer. Dr. Snyder is a professor in the Abraham S. Fischler College of Education and School of Criminal Justice and Dr. Kramer is an associate professor in the H. Wayne Huizenga College of Business and Entrepreneurship at Nova Southeastern University (NSU) in Fort Lauderdale, FL. This study is being funded by NSU's President's Faculty Research and Development Grant.
What is the study about?
We are conducting a research study to explore how we can use immersive virtual reality in higher education.
Why are you asking me?
I am calling you because you indicated on your questionnaire that you are willing to participate in a follow up interview regarding your perceptions about your experience using virtual reality in Dr. Kramer's Fall 2021 Quality Management course.

Thank you so much for your interest. Before we begin the interview, I'd like to ask you a few questions to make sure you are, in fact, eligible to participate in the interview.

1. Were you an active student in Dr. Kramer's Fall 2021 Quality Management course? [Circle yes/no]
2. Did you take part in using the Oculus Quest to explore various Quality Management scenarios? [Circle yes/no]
3. Are you able and comfortable communicating verbally in English via Zoom/phone? [Circle yes/no]

[If any answer was "no,"] I am sorry, the answer to all of the questions I asked has to be "yes." Thank you so much for your time and interest. Have a wonderful day! *[End call.]*
[If all answers were "yes,"] You are eligible to participate in an interview.

Next, I am going to read through information that is required in order for me to obtain your informed consent. Once I read the information, I will ask you formally to consent to be in an interview. It should take about ten minutes to go over everything. Is that okay? *[If answer was "yes," proceed by reading the informed consent information; if answer was "no," ask if there would be a better time to call back.]*
[If no] I understand completely. Thank you again for your time and interest in the study. Have a great day! *[End call.]*

What will I be doing if I agree to be in the study?
We are asking that you to participate in one 30 to 45-minute interview via Zoom (or over the phone)with possible follow-up calls or e-mails to answer questions you may not be able to answer off the top of your head. The interview will be semi-structured. This means that the questions are all written out ahead of time but you can provide extra information that is important and we may have not included. [You will be provided a copy of the interview questions ahead of time, so you can better prepare.]

Is there any audio or video recording?
This study will include audio recording of your interview using a digital handheld recorder. This audio recording will be available to be heard only by the IRB approved research team. After the interview is complete, the recording will be moved from the recording device to a password-protected file on the principal investigator's password-protected, cloud-based drive. A number will be assigned to the file and all of your study data will be managed through this identifier, not by your name. Once the number is assigned to the file, the recording will be transcribed by a third-party transcription service and analyzed by one of our research team members using a software tool that is used to help researchers organize themes from across the participant interview transcripts. We will review the themes that come from your interview and others we conduct to better understand how to best design and use VR vignettes in our college courses.

The digital file of the interview will be kept for 36 months (3 years) from the end of the study and destroyed after that time by permanently deleting the files off of the drive. Because your voice will be potentially identifiable by anyone who hears the recording, your confidentiality for things you say on the recording cannot be guaranteed although the researcher will try to limit access to the tape as I just described. When the project is finished and results are reported, no individual will be identified in any way.

We are almost done. I have just a few more things I am required to tell you.

What are the dangers to me?
Risks to you are minimal, meaning they are not thought to be greater than other risks participants experience every day. Being recorded means that confidentiality cannot be promised. You may not learn anything from participating in the interview and you may not find the information interesting. There may be other risks that cannot be predicted.

Are there any benefits for taking part in this research study?
You will not benefit directly from participating in this interview.

Will I get paid for being in the study? Will it cost me anything?
There is no cost for participation in this study. Participation is completely voluntary.

How will you keep my information private?
All information obtained in this study is strictly confidential unless disclosure is required by law. All data will be stored for 36 months (3 years) in a password-protected file on the principal investigator's password-protected cloud drive. Your name will not be used in the reporting of information in publications or conference presentations.

What if I do not want to participate or I want to leave the study?
You have the right to leave this study at any time or refuse to participate. If you do decide to leave or you decide not to participate, you will not experience any penalty. If you choose to withdraw, any information collected about you before the date you leave this study will be kept in the research records for 36 months from the conclusion of the study and may be used as part of the research.

If significant new information relating to the study becomes available, which may relate to your willingness to continue to participate, this information will be provided to you by the investigators.

Do you have any questions or would you like me to repeat part of the information I have just provided?

If you have any questions about the research, your research rights or any research-related injury, you may contact the principal investigator, Dr. Martha Snyder at (954) 262-2074. You may also contact NSU's Human Research Oversight Board (IRB) at (954) 262-5369 or Toll Free: (866) 499-0790. You may also request a hard (written) copy of the information I am presenting today.

Voluntary Consent by Participant:
Now, in order to obtain your formal consent to participate in the interview I need to record this next part of our conversation. Is that okay?

[If no] I understand completely. Thank you again for your time and interest in the study. Have a great day! *[End call.]*

[If yes, turn on the recording device.]

Okay, I am turning on the recording device now. The first thing I would like you to do is please state your first and last name. [Record participant's first and last name].

Thank you. Today's date is *[record today's date].* Next, please state "yes" or "no" to the following questions *[Make each statement below and record participant's response.]*

1. This study has been explained to you. [Yes/No]
2. Your questions about this research study have been answered. [Yes/No]
3. You have been told that you may ask the researchers any study related questions in the future or contact them in the event of a research-related injury. [Yes/No]
4. You have been told that you may ask Institutional Review Board (IRB) personnel questions about your study rights. [Yes/No]
5. You are aware that you are entitled to a copy of the information that was read to you after you verbally consent to participate in the study. [Yes/No]
6. You voluntarily agree to participate in this study entitled "Formative Research on Instructional Design Theory for Immersive Virtual Reality in Higher Education."
7.

Thank you very much for agreeing to participate in this interview. Now, let's begin.
[End call.]

Participant's Name: _____ Date: _____
Name of Person Obtaining Verbal Consent: _____ Date: _____
Signature of Person Obtaining Verbal Consent: _____Date: _____

Appendix D: Immersive Virtual Reality Perceptions Questionnaire

Immersive Virtual Reality Perceptions Questionnaire

Introduction

You are receiving this survey because you are a student in PIM5450: Quality Management and have agreed to participate in a research study about how virtual reality (VR) can be used to facilitate learning. The purpose of this survey is to get your feedback about your experience using VR in the course. It should take no longer than 10-15 minutes to answer the questions. Completing the survey implies your informed consent to participating in this research study. No identifying information will be included in the research report. This research study is monitored by Nova Southeastern University IRB protocol number 2021-236 for research compliance. If you have any questions or concerns, you may contact Marti M. Snyder, Ph.D. (smithmt@nova.edu) or 954-262-2074, Principal Investigator (PI), Abraham S. Fischler College of Education and School of Criminal Justice, or Steven Kramer, Ph.D. (sk863@nova.edu) or (954) 288-4782, Co-PI, H. Wayne Huizenga College of Business and Entrepreneurship, Nova Southeastern University.

1. What was your assigned 360-degree video viewing mode?

   VR Headset (Oculus)

   Computer PC with Chimera App

   Mac Computer with SharkMedia

2. Which 360-degree videos did you watch using your assigned viewing mode? (Select all that apply.)

   City Furniture-Strategic Planning Process

   City Furniture Quality Department Meeting

   City Furniture Chair Assembly Team Meeting

   City Furniture: Chair Assembly-Wooden Chair 1

   City Furniture: Metal Chair Assembly Part 1

   City Furniture: Cross Functional Weekly Meeting

   City Furniture: Customer Care Department Meeting

3. Using immersive virtual reality for learning increased my interest in the subject matter.

   1 2 3 4 5

   Strongly Disagree Strongly Agree

4. Immersive virtual reality allowed me to experience the course content in a useful way.

1 2 3 4 5
Strongly Disagree Strongly Agree

5. Using immersive virtual reality enhanced my learning experience.

1 2 3 4 5
Strongly Disagree Strongly Agree

6. Using immersive virtual reality made it easier for me to understand the course content.

1 2 3 4 5
Strongly Disagree Strongly Agree

7. Using immersive virtual reality made it easier for me to collaborate with my classmates.

1 2 3 4 5
Strongly Disagree Strongly Agree

8. Overall, immersive virtual reality was useful in supporting my learning.

1 2 3 4 5
Strongly Disagree Strongly Agree

9. On a scale of 1 to 5 where 1=not at all important and 5=very important, how important is it to you to use experiences afforded by immersive virtual reality technology to help you improve your quality management skills?

1 2 3 4 5
Not at all important Very important

10. What suggestions do you have for making your immersive virtual reality experience in this course more useful in your ability to perform quality management skills?

11. Learning to use immersive virtual reality was easy for me.

1 2 3 4 5
Strongly Disagree Strongly Agree

12. I find immersive virtual reality easy to use.

1 2 3 4 5
Strongly Disagree Strongly Agree

13. My interaction with immersive virtual reality was clear and understandable.

    1 2 3 4 5
    Strongly Disagree Strongly Agree

14. It was easy for me to become skillful at using immersive virtual reality.

    1 2 3 4 5
    Strongly Disagree Strongly Agree

15. In immersive virtual reality, I was less distracted than in other learning environments (e.g., face-to-face classroom, online, etc.).

    1 2 3 4 5
    Strongly Disagree Strongly Agree

16. On a scale of 1 to 5 where 1=not at all important and 5=very important, how important is it to you that IVR is easy to use?

    1 2 3 4 5
    Not at all important Very important

17. What suggestions do you have for making it easier to use immersive virtual reality in this course?

18. I enjoy using immersive virtual reality.

    1 2 3 4 5
    Strongly Disagree Strongly Agree

19. Using immersive virtual reality is pleasant.

    1 2 3 4 5
    Strongly Disagree Strongly Agree

20. On a scale of 1 to 5 where 1=not at all important and 5=very important, how important is it to you that immersive virtual reality is enjoyable?

    1 2 3 4 5
    Not at all important Very important

21. What suggestions do you have for making your immersive virtual reality experience more enjoyable?

22. Assuming I had access to immersive virtual reality for learning in the future, I intend to use it.

	1	2	3	4	5	
Strongly Disagree						Strongly Agree

23. I would like to use immersive virtual reality in the future.

	1	2	3	4	5	
Strongly Disagree						Strongly Agree

24. I would like to use immersive virtual reality in future courses.

	1	2	3	4	5	
Strongly Disagree						Strongly Agree

25. Did you participate in simultaneous viewing of any of the 360-degree videos with Dr. Kramer?

    Yes

    No

26. If you participated in the simultaneous video viewing with Dr. Kramer, what are your impressions?

    What value do you see in meeting in a virtual space together simultaneously with faculty and/or fellow classmates?

    What potential negative issues do you see with this type of simultaneous viewing experience?

27. What suggestions do you have for increasing the likelihood that you will use immersive virtual reality in future courses and/or for learning in the future.

Appendix E: IRB Approval Letter

NOVA SOUTHEASTERN UNIVERSITY
Institutional Review Board

MEMORANDUM

To: Marti Snyder, Ph.D.
College of Engineering and Computing

From: Ling Wang, Ph.D.
College Representative, College of Engineering and Computing

Date: May 28, 2021

Subject: IRB Exempt Initial Approval Memo

TITLE: Formative Research on Instructional Design Theory for Immersive VR in Higher Education– NSU IRB Protocol Number 2021-236

Dear Principal Investigator,

Your submission has been reviewed and Exempted by your IRB College Representative or their Alternate on **May 26, 2021**. You may proceed with your study.

Please Note: Exempt studies do not require approval stamped documents. If your study site requires stamped copies of consent forms, recruiting materials, etc., contact the IRB Office.

Level of Review: Exempt

Type of Approval: Initial Approval

Exempt Review Category: Exempt 1: Educational research in educational settings

Post-Approval Monitoring: The IRB Office conducts post-approval review and monitoring of all studies involving human participants under the purview of the NSU IRB. The Post-Approval Monitor may randomly select any active study for a Not-for-Cause Evaluation.

Annual Status of Research Update: You are required to notify the IRB Office annually if your research study is still ongoing via the *Exempt Research Status Update xForm.*

Final Report: You are required to notify the IRB Office within 30 days of the conclusion of the research that the study has ended using the *Exempt Research Status Update xForm*.

Translated Documents: No

Please retain this document in your IRB correspondence file.

CC: Ling Wang, Ph.D.

Office of Sponsored Programs (OSP)

Appendix F: Immersive Virtual Reality Demographic and Pre-Screening Questionnaires–Summary of Results

The survey opened on Sunday, August 15, 2021 and closed on Tuesday, August 31, 2021

The course ran from August 23, 2021 to Sunday, October 17 (8-week course)

Started with 16 students and ended with 14. Eight students used the Oculus headset (one remote) and the rest were local. The remaining six watched the 360-degree videos on the computer through SharkMedia.

Survey Results Summary

A total of 16 students completed the survey. Six were male and 10 were female.
Students ages ranged between 24-50 with one over 50.

Twenty-five percent (n=4) of the students identified as White; 25% (n=4) identified as Black or African-American; 31% (n=5) identified as Hispanic, Latino, or Spanish Origin; 6% (n=1) identified as Asian and 12% (2) identified as Middle Eastern or North African.

The majority (10) indicated they have never participated in a computer-based simulation, video game, where they were placed within a virtual world/space either using a headset or console.

Of the six participants who had previous experience, most did not experience symptoms. Five of the six reported symptoms as follows:

Fatigue – none (n=4); moderate (n=1)
Headache – none (n=3); slight (n=1); moderate (n=1)
Feeling Nervous or Anxious – none (n=3); slight (n=1); moderate (n=1)
Eye Strain – none (n=2); slight (n=1); moderate (n=2)
Difficulty Focusing – none (n=4); moderate (n=1)
Increase in Salivation – none (n=4); slight (n=1)
Sweating – none (n=3); slight (n=1); moderate (n=1)
Nausea – none (n=3); slight (n=1); moderate (n=1)
Difficulty Concentrating – none (n=4); moderate (n=1)
Fullness of the Head – none (n=4); moderate (n=1)
Blurred Vision – none (n=3); moderate (n=2)
Dizziness with Eyes Open – none (n=4); moderate (n=1)
Dizziness with Eyes Closed – none (n=4); moderate (n=1)
Vertigo – none (n=3); slight (n=1); moderate (n=2)
Burping – none (n=5)
Stomach Awareness – none (n=4); slight (n=1)

Over half (n=10) reported having little to no experience with the use of computer games including computer-based games, simulations, virtual reality, augmented reality, and mixed reality. Those who had some experience reported playing games such as boxing, sports, workouts, Fruit Ninja, and Dance Revolution using a VR headset and war games such as Battlefield and Call of Duty and sports games, and MarioCart accessed via a gaming console.

Students who had previous experience using VR and a gaming console used the Oculus Quest, Sony PlayStation, XBOX, PS5, and Wii.

Regarding their opinion of VR technology, 40% (n=7) hold a very positive or positive opinion; 47% (n=8) hold a neutral opinion, and 6% (n=1) holds a very negative opinion.

Overall, 12 of the 16 reported anticipating not having any difficulties using a VR headset. For participants were not sure.

When asked about their thoughts about using VR for learning, most participants reported being open to the experience but requested more information and training. Two students commented about their preference not to use VR for learning stating either that they have experienced dizziness watching 3D movies and prefer not to try VR or they simply prefer experiencing an event in person and are “turned away” from using anything relating to virtual experiences.

Appendix G: Immersive Virtual Reality Perceptions Questionnaire–Summary of Results

The survey opened on Friday, October 8, 2021 and closed on Friday, October 29, 2021.

Six of the eight participants who used the Oculus headset to watch the 360-degree video vignettes completed the survey.

There were seven video vignettes presented throughout the semester. Each video aligned with a course topic. All videos were provided as supplementary material meaning that students were not required to watch them. All seven videos were recorded at City Furniture and included 1) strategic planning process, 2) quality department meeting, 3) chair assembly team meeting, 4) chair assembly (wooden chair); 5) chair assembly (metal chair); 6) cross-functional weekly meeting, and customer care department meeting.

All six students reported watching as least one of the videos. The most popular videos were the strategic planning process and customer care department meeting.

All but one person (n=5) agreed or strongly agreed that immersive virtual reality for learning increased their interest in the subject matter and allowed them to experience the course in a useful way.

Most of the participants (n=4) agreed or strongly agreed that using immersive virtual reality made it easier for them to understand the course content.

When asked whether using immersive virtual reality made it easier to collaborate with classmates, there was a neutral response with n=5 stating they disagree or were neutral about the question.

Most of the respondents (n=5) felt that immersive virtual reality was useful in supporting their learning.

However, when asked how important experiences afforded by immersive virtual technology were to improve their quality management skills, responses were mixed with respondents reporting across the board from not at all important to very important.

When asked what suggestions they had to making their immersive virtual reality experience in this course more useful in their ability to perform quality management skills, participants noted that they wanted more interactive meetings in VR with the instructor and classmates and also to integrate the video vignettes into the course as a formal assignment with points. Some students noted difficulty in finding the time to watch the video especially when they weren't required.

When asked about whether learning immersive virtual reality was easy, participants had mixed feelings (strongly agree n=2); (neutral, n=2); (strongly disagree n=2).

When asked about whether immersive virtual reality was easy to use, participants had mixed feelings (strongly agree n=2); (neutral, n=2); (strongly disagree n=2) and most (n=4) felt that it was very important that IVR is easy to use.

Suggestions they had for making it easier to use included providing more instruction at the beginning of class on how to use the technology. Also, having someone who could guide them in the use of the IVR would be helpful.

When asked whether their interaction with immersive virtual reality was clear and understandable, most (n=5) agreed.

Also, all participants (n=6) indicated that they agreed that it was easy for them to become skillful at using immersive virtual reality.

Four out of six participants felt that they were lest distracted in immersive virtual reality as opposed to other learning environments (e.g., classroom, online, etc.).

Enjoyment

When asked whether participants enjoyed using IVR responses were mixed with n=3 agreeing to this statement and n=3 remaining neutral. They also were mixed in their feelings that using IVR was "pleasant."

However, when asked how important enjoyment was when using IVR, most (n=4) said it was important or very important.

Suggestions for making IVR more enjoyable included participating in IVR as a group/more interaction, having better sound and graphics quality/resolution, having a more comfortable headset (too heavy for long periods of time and caused headache).

Intention to Use

When asked whether they would participate in IVR again if they had access to it for learning in the future responses were mixed with half (n=3) indicating they would and half (n=3) indicated they wouldn't be as likely.

When asked whether they would like to use IVR in the future, responses were mixed with most indicated that they would like to (n=4).

When asked specifically about using IVR in future courses, again, responses were mixed with most (n=4) indicating they would.

When asked whether they participated in the simultaneous viewing of the IVR with Dr. Kramer, all (n=6) indicated that they did.

When asked about the simultaneous video viewing with Dr. Kramer participants overall liked the experience and felt that it was more intimate ("like we were really together"), they could talk about what they were watching together, and analyze the video "as a team." Some of the downsides noted included feeling lightheaded, feeling uncomfortable after a while because the headset was heavy, and being distracted due to the fact that the technology was new and participants were "curious to look and play around and move their virtual bodies, like waving at others."

Finally, when asked for their suggestions for increasing their likelihood of using IVR in future courses, recommendations included improving the video and audio quality, providing the capability to show facial expressions, doing some tutorials and "practice runs" at the beginning of class, and integrating the IVR component into the course rather than having it as optional or an "add-on."

Author Note

Martha M. Snyder, Ph.D., PMP, SPHR, CHSE, is a Professor in the Department of Education at Abraham S. Fischler College of Education and School of Criminal Justice in Nova Southeastern University. Please direct correspondence to smithmt@nova.edu.

Steven Kramer, Ph.D., MBB, is Professor of Decision Sciences in the H. Wayne Huizenga College of Business and Entrepreneurship at Nova Southeastern University. Please direct correspondence to sk863@nova.edu.

Diane Lippe, Ed.S., is the Executive Director of the Learning and Educational Center at Nova Southeastern University. Please direct correspondence to lippe@nova.edu.

Sharan Sankar is an Undergraduate Student in the Razor's Edge Research Program and the 4+4 Dual BS/DO at Nova Southeastern University.

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