Assignment 8: Culminating Research Study

Rodney Clarkson

Northcentral University

Utilization of Content Analysis to Identify IVR Tool Implementation

Introduction

Successful transfer of knowledge has always been the foundation of human development since ancient times. As educators, it is incumbent to explore new ways of acquiring knowledge and communicating the same easily, fast, and effectively (Babich, 2019). All prosperous societies are the result of intensive and sustained investment in quality and equitable education, and technology has emerged as an effective medium for facilitating these two components.

Virtual reality is today an acceptable learning and teaching modality. In this capstone project, Virtual Reality (VR) and Immersive Virtual Reality (IVR) will be used interchangeably. Immersive Virtual Reality in Education is a recent phenomenon but has already managed to reach critical mass in terms of accessibility, functionality, and affordability. There is widespread dialogue on its potential as an educational application and specifically IVR's learning affordances and its impact on learners within the K-12 curriculum (Jowallah, Bennett, & Bastedo, 2018).

Virtual Reality (VR) refers to enclosed experiences within computer-generated spaces that have shut out physical surroundings to a large extent. Augmented Reality (AR) are experiences that superimpose digital elements onto real-world backgrounds or entities (Markowitz, Laha, Perone, Pea, & Bailenson, 2018). Immersive technologies are evolving with a multifaceted spectrum giving rise to a mix of digital and real worlds, now referred to as Mixed Reality (Bonasio, 2019).

The different features of IVR deliver distinct forms of immersion and feelings within the simulated environment. Users can have a "look around" experience or limited interaction

and navigation (Parong & Mayer, 2018). IVR spaces can also be overly immersive, with users freely manipulating, interacting, navigating, and creating customized experiences (Southgate, Blackmore, Pieschl, Grimes, McGuire, & Smithers, 2019).

Southgate (2018) posited that immersive virtual reality has no clear definition and classifies it as; virtual reality facilitated through a head-mounted display (HMD) and projects visuals directly to the user and tracks users' position in space. According to Bonasio (2019), the state of immersion in VR wholly engages users in an activity. It is an effective tool for knowledge transfer and identity, essential elements for positive learning outcomes. IVR's features are intensely experiential, eliciting diverse emotional and physiological responses on users, particularly when place and credible illusions are amplified (Southgate, 2018).

According to Johnston, Olivas, Steele, Smith, & Bailey (2017), most of these new VR tools for education rarely contain explicit pedagogical features that are aligned to specific course designs. Markowitz, Laha, Peron, Pea & Bailey (2018) study also recognizes the absence of clarity between pedagogy and technology, issues that have a negative impact on teaching and learning.

Even within these virtual spaces, successful learning is dependent on how well these tech tools exploit user's cognitive development and perceptions. Hu-Au & Lee (2017) paper emphasis an emerging educational shift from the *information age to experience age,* the former focused on communicating and accumulation of information, while the latter thrives on the use of interconnected mobile devices for sharing real-time experiences. The traditional instructional approach has failed to meet the needs of contemporary learners who are ideally *digital natives* and prefer real-world, real-time experiences that are available through VR environments.

IVR in Education

Educator's interest in IVR for learning and teaching is derived from our natural affinity for progress and search for complementary tools to facilitate the same. The traditional style of instruction is also losing meaning, as it has dawned, students have different ways of absorbing knowledge, and require distinct engaging and collaborative environments. IVR spaces enhance student engagement, collaboration skills, and generally ease student cognitive load, allowing them to process information faster and better (Babich, 2019). IVR plays an important role in supporting modern educational settings.

Bonasio (2019) points out the failure of traditional instructional approaches to effectively transfer knowledge, as students who are academically proficient are unable to use acquired skills in real-world situations. According to Bonasio (2016), IVR facilitates a situated learning model by motivating students to build their own learning experiences. The positive impact of IVR for learning and teaching is now widely acknowledged by educators. However, there is a need to explore experiences that immerse learners in relevant contexts offering realistic practices, strong narratives, and connections to real-world outcomes (Bonasio, 2019).

New IVR tools for education create simulated environments that fully immerse users, and these experiences can now be delivered through a smartphone fixed on a viewer or a Head-Mounted Display (HMD) that provides users with a 360-degree view projected from the devices. The emerging ease of access regarding educational IVR can help transform the modern classroom and readily support our modern students. Virtual reality tools have become pervasive with leading tech firms – Facebook, HTC, Sony, Microsoft, and Google competing to develop revolutionary tools for education. Before these new accessible, functional, and

affordable applications, IVR tools were beyond reach for most educational institutions operating on the margins.

New and emerging tools are entering the market daily, and it is a challenge for educators to keep up with these new developments. Educators are the ultimate decision-makers when it comes to curriculum development. Still, as non-tech experts, they urgently need an affordance rubric that can effectively be used to rate IVR tools for integration in classrooms.

Importance of Exploring Affordances of IVR Educational Tools

Since it is clear IVR has a place in the modern classroom, the obvious next step is to analyze how IVR provides learning affordance to students. Influential American psychologist James Jerome Gibson's *affordance theory* is the basis of our modern interpretation of visual perception. According to the theory, *affordance* exists as long as an animal or person takes the initiative to exploit it (Bower & Sturman, 2015). Affordance can also be defined as a design feature of a device that indicates how it can be put to use. IVR design features are key to maximizing learning affordances. For educators, the perceived affordances determine user actions or ways of completing the actions with the related IVR tools.

Effective utilization of IVR tools for learning and teaching depends on the instructor's ability to appreciate the needs within the learning context and subsequently select and apply the technologies to fulfill educational requirements. Most of the IVR tools that are available for education are not ideally designed for teaching and learning, and it is up to educators to analyze the affordances and limitations of these technologies to creatively realign them to suit educational contexts (Brown & Green, 2016). Technology is quickly evolving, and educational researchers must now focus on analyzing the educational merits of new and

emerging tools based on their capabilities. The selection of IVR for tools for classrooms must be based on explicit identified educational needs instead of mere intuitions.

For educators, IVR affordances are identified through trial and error use of the technologies, and reflections subsequently allow the discovery of new affordances to be applied in teaching. In addition, students' interaction and response to an IVR activity will also assist teachers in identifying inherent affordances. For example, Minocha et al. (2017) exploratory study on Google Expeditions identified ten affordances that research participants described as their experiences and perceptions, when exposed to or interacting in, GEs VR environments. It is incumbent for educators to identify IVR affordances that are aligned to pedagogical expectations of specific course designs and equally support student learning needs (Jowallah, 2018).

Low-cost IVR tools offered through Head-Mounted Displays are today, core to VR experiences, with *Google Cardboard* and *Samsung Gear VR* emerging as low-budget tools that provide users with virtual experiences which include flexibility of movement as the tools, are not attached to a computer (Jowallah et al., 2018). These low-budget IVR tools have minimal technical requirements, can help students when used to enhance learning experiences, and are effective in delivering instructions.

Introduction to the Problem

Educational researchers are yet to define categories for IVR educational tools fully. Johnston et al. (2017) research identifies and categorizes principles and practices of pedagogy in select virtual reality educational applications and asserts that the majority delivered experiential learning experiences. Johnson-Glenberg (2018) explored the design principles of VR educational applications and found a positive impact on academic outcomes. According to Johnson-Glenberg (2018), two profound affordances that can significantly contribute to

educational outcomes are; *feeling of presence* and *embodied gestures with a capacity to manipulate content in 3-D.* Kaminska et al. (2019) paper provides insight on VR applications in education and recognized their capacity for cross-curricular learning, largely through the use of Head-Mounted Devices that provide 3-D immersive experiences of real-world situations. Kamniska et al. (2019) and Johnson-Glenberg (2018) assert the need to establish affordances that positively impact learning and teaching approaches.

Jowallah et al. (2018) report on leveraging affordances of VR applications in the K-12 curriculum and acknowledges the need for scalable systems for ease of adoption as virtual reality is bound to transform education in the future. Minocha, Tudor & Tilling (2017) exploratory study focuses on the technological affordances of Google Expeditions in providing users with experiential learning models through virtual field trips, experiences that improve on academic outcomes. Jowallah et al. (2018) and Minocha et al. (2017) report on the need for affordable and accessible IVR tools that deliver appropriate educational experiences as previous applications were largely beyond the reach of cash strapped educational institutions.

Bower & Sturman (2015) study sought to identify educational affordances of wearable technologies to help educators understand opportunities that are provided for by these devices. The two researchers acknowledge the lack of literature exploring the possibilities of using wearable technologies for teaching and learning, and this limits their adoption in the classroom.

Statement of the Problem

Despite clear research findings on IVR's positive learning affordances, there exists a lack of blend between pedagogy and technology concerning immersive virtual reality in education. Teachers are facing challenges in identifying and implementing relevant

affordances that are effective in improving learning and teaching. IVR tools for education are evolving, and education researchers must discover exactly which affordances improve on educational outcomes.

The purpose of a content analysis study is to facilitate understanding of the intrinsic affordances offered by low-cost devices to assist educators in evaluating and selecting appropriate applications for use in classrooms. The results will be the basis for developing a framework that will help with the predictive assessment of IVR tools. This outline can be used by non-tech curriculum experts and applied in multiple course designs to help draw attention to logical aspects of assessing any IVR educational tool. Providing teachers with a tool for evaluating the potential of an IVR application is a needed resource as teachers navigate the best IVR implementation practices.

For educators to maximize the advantages of IVR tools for education, they must rely on evidence-based research of various affordances that are effective in particular course design. Knowledge of these affordances will also enable educators to assess and choose IVR tools through a multidimensional evaluation of technical, functional, and pedagogical framework (Johnston et al., 2017).

Parong & Mayer (2018) recognize educators need to find new ways that multimedia learning mediums can help students in IVR environments, as low budget tools can be a source of educational equity and adequacy. Teachers are ideally experts in their curriculum matters and are not yet fully conversant with the best criteria for identifying affordances of IVR educational tools. Additionally, there is an exponential increase in the number of IVR tools in the market. These two factors make it difficult for instructors to stay current with technological innovations that claim to transform learning and teaching.

Rationale for Utilizing Qualitative Content Analysis

The proliferation of IVR tools for education has seen a rise in literature exploring the inherent affordances of these applications. Qualitative content analysis in its nature systematically transforms volumes of text into a well organized and succinct summary of important results (Erlingsson & Brysiewicz, 2017). Content analysis research is effective in analyzing theoretical issues found in the existing literature on IVR educational tools. In choosing qualitative content analysis, the objective is to develop a rubric from the results and identify explicit pedagogical affordances that improve teaching and learning within the virtual environment. This research approach is logical and objective for identifying and evaluating IVR tools for education to allow for effective integration in classrooms, as the approach is non-intrusive and can provide insightful understanding of complex phenomena of human interactions.

The population will be public content describing affordances of IVR educational tools found online and published within the last five years. The sample will be restricted to low-cost IVR tools explicitly used for educational purposes. Content analysis is applicable to multiple written texts, notwithstanding the source (Erlingsson & Brysiewicz, 2017). To ensure trustworthiness of the content analysis, the data collection approach will be based on the following research questions: How well IVR tool works to enhance the conceptualization of abstract concepts? How well IVR tool works to facilitate instructors in their specific course designs? How well IVR tool is aligned to experiential learning theories? Through inductive reasoning, the text is analyzed, and the researcher maintains an open mind to avoid biases and as a way of discovering meaningful subjects for answering research questions.

The research supposes that most IVR educational applications are likely to have an experiential learning element. IVR offers learners the opportunity to experience environments that are remote and difficult to access, socially undesirable, environmentally harmful, or too costly to explore. Experiential learning can be delivered through real or artificial

environments, while direct instruction and situated cognition developed in IVR applications require customized spaces that facilitate these experiences (Johnston et al., 2017). IVR tools based on experiential theory are ideal as they are adaptable to the existing learning spaces.

To narrow down relevant literature, the online research will capitalize on the following keywords; virtual reality, immersive learning, 3-D learning environments, IVR tools affordances, simulations, low-cost IVR experiences, and IVR pedagogical affordances in K-12 curriculum. There is a vast amount of descriptive literature on IVR educational tools provided by development professionals, concept creators, and sellers.

Qualitative content analysis is a reflective process that involves; condensing data into suitable units for analysis, providing codes to the units, grouping together related codes into categories, and finding a theme that expresses underlying meaning for the categories (Erlingsson & Brysiewicz, 2017).

Why a Rubric?

The content analysis study, while identifying affordances of IVR educational tools, aims to support their effective use for specific course designs and providing students with meaningful learning experiences. Educators regularly use rubrics for articulating expectations of course assignments, listing important content connections, and levels of quality. A rubric for evaluating IVR educational tools for implementation will rely on existing affordances to articulate appropriate fits that are aligned to relevant course designs and learning expectations.

There is a prevalent need for an evaluation rubric that examines every aspect of VR tools designed for educational purposes. An online search for an existing rubric, reveals none is available that based on a reliable and valid research study. Current literature identifies

numerous affordances of learning technologies, but there is an absence of a clear framework that specifically responds to instructor needs and supports implementation in classrooms.

Selecting IVR tools should be based on preferred learning experiences, instructional activities, and expected outcomes. The content analysis results can provide an evidence-based framework for creating a rubric that responds to the distinct educational needs of both students and teachers. The rubric will also allow educators to independently evaluate IVR tools on an ad hoc basis to fulfill specific areas of interest.

Literature Review

As previously mentioned, the education sector is experiencing a transformation with traditional methods of instruction becoming redundant, largely due to the introduction of new and emerging technology tools in the classroom. Immersive VR in education has attracted interest due to its ability to provide students with experiential learning experiences. Sustained investments by leading tech firms in IVR applications have enabled technology to reach critical mass in terms of accessibility, functionality, and affordability (Jowallah, Bennett, & Bastedo, 2018). Affordances in virtual reality environments describe the inherent benefits within these virtual spaces or devices experienced by the users.

According to Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero (2016), IVR tools also offer students opportunity to develop their collaboration and critical thinking skills and emotional intelligence, abilities that are important in future job markets.

This literature review explores current literature focusing on IVR in education and the pedagogical affordances of IVR applications needed to improve teaching and learning within the K-12 environment. This review covers literature exploring a blend between pedagogy and

technology within a balanced framework for the successful integration of IVR in existing classroom systems.

The review is structured to explore the following topics: background of IVR in education, learning affordances of IVR, low-cost IVR educational experiences; and ethical and safe use of IVR in K-12 education.

Immersive Virtual Reality: A Background

Virtual Reality (VR) refers to enclosed experiences within computer-generated spaces that have shut out physical surroundings to a large extent. Augmented Reality (AR) are experiences that superimpose digital elements onto real-world backgrounds or entities (Markowitz, Laha, Perone, Pea, & Bailenson, 2018). Immersive technologies are evolving with a multifaceted spectrum giving rise to a mix of digital and real worlds, now referred to as *Mixed Reality* (Bonasio, 2019). This literature review will focus on IVR experiences in a broader context to include all virtual technologies common in educational settings.

The different features of IVR deliver distinct forms of immersion and feelings within the simulated environment. Users can have a "look around" experience or limited interaction and navigation (Parong & Mayer, 2018). IVR spaces can also be overly immersive, with users freely manipulating, interacting, navigating, and creating customized experiences (Southgate, Blackmore, Pieschl, Grimes, McGuire, & Smithers, 2019).

Virtual reality has been in existence for quite a while, with NASA using it for realistic training simulations, though there is a lack of clear definition for immersive experiences. Southgate (2018) posits that VR facilitated by Head Mounted Display (HMD) provides us with a clear perspective of the technology. According to Southgate (2018), HMDs provide users with intense experiential experiences that elicit diverse emotional and physiological

responses, particularly when place and credible illusions are amplified, features that have attracted the interest of educators.

Bonasio (2019) concurs with Southgate (2018) and states that immersion in VR wholly engages users in an activity and is an effective tool for knowledge transfer, the reason for the emerging interest, and need for implementation in classrooms.

Jowallah, et al. (2017) posits that technology advancement presents educators with an opportunity for innovation to improve outcomes, and VR has evolved to become an effective learning and teaching modality. Previously, VR systems were beyond reach for schools due to financial constraints, but this is changing due to the proliferation of smart devices that allow for affordable virtual experiences (Jowallah et al., 2017).

Recent developments have seen the emergence of standalone virtual devices with computing processors inbuilt in HMDs, providing users with benefits similar to those of high-end devices. However, they all must be configured for educational purposes (Brown & Green, 2016). Educators need to identify different types of IVR and their functionality to clearly understand the effect on children during different cognitive development.

Jowallah et al. (2017) recognize the need to explore issues of safety and health for young learners as the existing applications are largely focussed on enhancing engagement and physical interaction.

Learning Affordances of IVR Tools

Learning affordances are the inherent features within IVR tools that facilitate users to gain and retain knowledge in an educational setting. Bonasio (2019) asserts that the most effective educational practices are based on social constructivist learning approaches. In constructivist learning, students are involved in learning real tasks in an environment that is

authentic and personally relevant to them. Bonasio (2019) paper, while acknowledging the affordances of IVR, states that correct deployment, pedagogical relevance, and consistency are the key to successful educational outcomes.

Bonasio (2019) explored ways IVR can improve learning outcomes through easing user cognitive load – allowing direct and first-person conceptualization of complex tasks and structures. Bonasio (2019) research cross-referenced pedagogical theory with case studies and data was collected through interviews with educational stakeholders. The paper is premised on; reducing user cognitive load increases engagement and allows learners to understand complex problems and retain acquired information for longer. Bonasio (2019) research builds on the need to identify learning affordances that are effective in easing learner cognitive load.

Leung, Zulkernine, & Isah (2019) equally recognizes the capacity of virtual reality to provide users with an exploratory learning environment that facilitates experimentation. Leung et al. (2019) research investigated the application of VR in encouraging interdisciplinary communication. In highlighting the impact of virtual reality over traditional learning approaches, their study identifies teaching of abstract subjects as an area that enjoys the benefits of IVR technology.

According to Leung et al. (2019), virtual reality simulations for students of astrophysics allows them to experience abstract aerospace in a 3D projection. Students involved in abstract courses experience limitations as they are not able to conduct experiments in classrooms and rely on their imagination and instructor’s explanation.

A convergence of thought on IVR's ability to transform learning is found in merging of learning theories with the technology. The distinct affordances of IVR need to be

aligned with the elements of theories in learning to effectively develop educational applications (Leung et al., 2019).

Templeton (2019) study examines the pedagogical effect of virtual learning spaces on a student's academic performance in K-12 settings. Southgate & Smith (2016) describes pedagogy as a conscious activity designed to improve learning. Of particular importance, regarding academic performance from Templeton (2019), is the finding of IVR devices increasing student motivation, interest, and collaboration amongst the users. Before the study, Templeton (2019) identified a lack of research on the affordances of virtual systems and their impact on educational outcomes and sought to fill the gap. Templeton's research asserts the positive learning affordances with IVR implementation and the need for more specific research regarding best practices for educational use.

Templeton (2019) research engaged students in K-12 and used 3D devices, whereby participants explored the world and other scientific phenomena, experiences that offered learners real-life experiences. Though Templeton (2019) concurs on the benefits of IVR for improved academic performance, the research faced limitations due to negative reactions by users who experienced motion sickness, excess stimulation, and technical hitches. In this regard, the scholar posits the need for greater investigation on user safety and health while engaging in virtual reality environments.

Johnston, Olivas, Steele, Smith, & Bailey (2017) paper sought to recognize and categorize apparent practices and principles of pedagogy, that are not expressed in select virtual reality applications for education. Johnston et al. (2107) found that majority of VR applications in the public domain offered experiential learning. Others were found to provide constructivism, discovery, situated, and direct learning models. According to Johnston et al.

(2017), educators and VR developers need to work together for clear pedagogical foundations that support curriculum improvement.

For educators learning affordances inherent in IVR, systems serve as a guide during purchasing, training of faculty, and aligning software and hardware to student and curriculum needs (Johnston et al., 2017). IVR systems are evolving, with better functional models being introduced in the market. However, due to this rapid development, Johnston et al. (2017) identified a gap in literature focusing on articulating pedagogy in educational virtual reality systems. Other than building on current literature, Johnston et al. (2017) study provide educators with new and improved ways of learning and teaching made possible by IVR applications. Johnson-Glenberg (2018) posit that application designers also need to understand the inherent affordances in educational tools that educators look for during the selection and evaluation of their products to enable them to make adjustments for subsequent improvements.

Johnston et al. (2017) acknowledge that virtual reality educational applications are becoming pedagogically sustainable and offering learners unprecedented opportunities to experience and understand the world. The available IVR applications provide students with different learning experiences, and it is upon teachers to identify the applications that maximize educational outcomes and with relevant pedagogies (Johnston et al., 2017).

Hu-Au & Lee (2017) paper lists important skills that students need in order to thrive in this digital age, and these include; creativity, empathy, computation knowledge, systems thinking, and abstract thinking. These critical skills are challenging to teach, and according to Hu-Au & Lee (2017), IVR in its features and functionality offers educators a unique opportunity to impart these skills. Hu-Au & Lee (2017) recognize the affordances within IVR

systems that improve on teaching and learning through authentic and powerful interactive immersive experiences

Hu-Au & Lee (2017) premise their paper on a shift from Information Age to Experience Age, with contemporary learners opting for learning experiences that are connected, shared, and technologically mediated. Traditional instructional models do not offer students these engaging experiences. Hu-Au & Lee (2017) emphasize the capacity of IVR to provide constructivist learning, an approach that enables students to discover new knowledge from meaningful interactions. This affordance allows students to engage in realistic problem solving and even enhances collaboration among peers, features that are lacking in traditional learning models.

Hu-Au & Lee (2017) identifies the absence of situated learning in current classroom settings, where students only memorize facts while isolated from the context. With IVR, students enjoy situated learning in a simulated environment that is easily accessible (Hu-AU & Lee, 2017).

Research from Johnson-Glenberg (2108) adds additional literature regarding learning affordances of IVR by exploring ways educational theories can be used to design immersive virtual reality environments to enhance learning experiences. According to Johnson-Glenberg (2018), two profound affordances in 3-D spaces positively impact on education; a sense of presence and embodied affordances of gesture and manipulation. The theory is premised on the ability of physical gestures in virtual environments to improve learning and knowledge retention.

IVR in education is still at a nascent stage, and there is an absence of design guidelines exclusively for educational purposes. However, Johnson-Glenberg (2018) theorize emerging hand controls induce embodiment and agency through expressive and compatible

movements with the educational content. Johnson-Glenberg (2018) concludes with a comprehensive set of design principles for educational IVR and hypothesizes what he refers to as the Necessary Nine which includes: scaffolding cognitive effort; guided exploration; immediate, actionable feedback; play-testing; build in opportunities for reflection; use hand controls for active, body-based learning; integrating gestures that map to the content to be learned; gestures are worth the time; and embed gesture as a form of assessment. (Johnson-Glenberg, 2018) provides clear direction on optimizing education IVR learning affordances.

Low-cost IVR Educational Experiences

Virtual reality systems though extensive, have, in the past, been costly and beyond reach for schools. The advent of smart mobile devices has given rise to a new type of virtual reality system that allows for low budget virtual experiences. To create these low-cost experiences, all that is required is a smartphone mounted on a virtual reality headset, with headphones providing audio sounds if need be. Low-cost VR tools have minimal technical requirements as they are standalone devices and can be powered by smartphones. Jowallah et al. (2018) recognize the need to explore low-cost IVR devices further to support extensive adoption of this transformative modality in the K-12 curriculum.

Díaz, Sánchez-Francisco, Aedo, & Onorati (2019) comparative study sought to evaluate whether low-cost IVR tools can enhance learning experiences. Díaz et al. (2019) employed Oculus Rift and Cardboard Glasses – IVR devices with distinct immersive and presence features – in their experiment. Their study, through an open research question, examined the impact on learning of a high fidelity device versus the impact of a low-cost, lower fidelity device. According to Díaz et al. (2019), no significant differences in spatial and experiential learning were noted between the two devices. Additionally, both devices delivered similar experiences and satisfaction.

Díaz et al. (2019) findings support the use of low-cost IVR tools for educational purposes as they provide users with similar experiences as high-cost devices. For educators, the focus should be to ensure learning interaction within virtual spaces remains vibrant rather than focusing on quality – fidelity – of the virtual world. Díaz et al. (2019) recognize the need for application designers to incorporate end user's contribution to developing meaningful and relevant VR educational experiences.

Vishwanath, Kam, & Kumar (2017) paper reports on their experience co-designing low-cost VR learning experiences for vulnerable communities in Mumbai, India. Their seven-week study exposed children to VR experiences and examined their perception, impact on educational goals, challenges, and end-user ideas for feasible solutions.

Vishwanath et al. (2017) study found that introducing VR in classrooms enhanced student engagement with target topics, and this was a result of representational fidelity offered by great immersive VR experiences. Vishwanath et al. (2017) research contradicts Díaz et al. (2019) assertions on the importance of high fidelity within IVR learning environments. According to Vishwanath et al. (2017), fidelity enabled students to have a more vivid interaction prompting deeper interest and curiosity about the subject area. Radianti & Wohlgenannt (2020) posits that *realistic environments* or *surroundings* are viewed differently, and the issue of fidelity depends on how users interact in these spaces. A "realistic enough" environment does not necessarily require high fidelity VR tools, as it also offers learners desired outcomes.

Yap (2016) study involved an instructional design project for use in a learning management system (LMS) facilitated by Google Cardboard, a low-cost 3D viewer. The research investigated high school student perceptions on social studies content viewed through a Google Cardboard. Yap (2016) study found that all participants that interacted in

VR spaces using Google Cardboard had positive experiences as the low-cost device allowed them to explore places they could never have visited. Additionally, results showed use of Google Cardboard enhanced student critical thinking and problem-solving skills, as most used the opportunity to come up with other uses of the device for learning.

Fransson, Holmberg & Westelius (2020) paper analyzed challenges and opportunities involved in implementing Head-Mounted Displays (HMD) VR in K-12 educational settings, from the teacher's perspective. Fransson et al. (2020) recognize the potential of using HMD VR in the K-12 curriculum due to its affordability, accessibility, and functionality. Their study involved interviews and informal conversations with teachers participating in a workshop for testing wired HMD VR in a university center and high school teachers involved in a project exploring and implementing mobile HMD VR for instructions. Fransson et al. (2020) discovered that the teachers were optimistic about VRs potential as an educational tool, though they remained cautious about its ability to 'revolutionize' education.

Fransson et al. (2020) focuses on teacher's views on the use of HMD VR in educational settings and emphasizes the need to align these applications to the K-12 curriculum through encouraging system designers to incorporate teacher input. This will ensure the content is customized and refined according to the prevalent teaching and learning theories. Low-cost IVR tools are accessible, functional, and affordable and can ease integration in existing classrooms, saving on costs of redesigning learning spaces. Overall, it is clear low-cost IVR systems have the capacity to transform the way we teach and learn. It is incumbent for educational researchers to identify affordances within these tools for effective implementation in classrooms.

Ethics and Safety of IVR Educational Tools

IVR offers educators limitless advantages, but there is a persisting debate on ethics and safety complexities, which these emerging technologies present. At the moment, little is known about the physiological impact of IVR on the individual. Virtual reality developers are in a race for competitive advantage, and state and federal regulators have difficulties monitoring and keeping them in check.

Successful integration of IVR tools in education depends on ethics and safety, more so for children exposed to these applications (Evans, 2018). Southgate et al. (2019) point at a child's cognitive development and the impact of highly immersive virtual environments on young users. It is critical for educators to factor cognitive dimensions of how young learners comprehend what is real and what is simulated (Southgate et al., 2019).

Bailey & Bailenson (2017), in examining IVR and the developing child postulate that, young children unlike adults, react differently to sensory salient and immersive applications, as these experiences are overly vivid and appear real. A child's cognitive and behavioral response to IVR, if real, may either have a positive or negative impact, prosocial education or increased materialism, respectively (Bailey & Bailenson, 2017).

The inherent affordances of IVR can be overwhelming to a child's automatic responses and cognitive abilities as these applications connect with human senses creating an illusion of being embedded in the simulated environment (Bailey & Bailenson, 2017). As such, young children can fail to comprehend the difference between what is real and what is virtual. From Bailey & Bailenson (2017) observations, the effect of IVR on children depends on age, cognitive ability, and type of immersive applications used.

Bailey & Bailenson (2017) acknowledge that education and psychology researchers have yet to fully explore how IVR impacts on cognitive development of young learners. Nonetheless, from the existing literature, the age set determines how a child reacts to IVR

exposure. In this regard, it is the responsibility of educators and IVR developers to establish what applications and content are appropriate and at what age. Sobel (2019) reports on the findings of a one-day convention organized at Arizona State University to reflect on how immersive media impacts child development at a time when these immersive media are becoming pervasive in the lives of children. Participants in the discussion included education leaders, researchers, pediatric medicine, technology policy, and application developers. Sobel (2019) and Bailey & Bailenson (2019) have a convergence of thought on IVR's capacity to potentially harm or benefit the user due to the application's perspective realism.

A notable feature of immersive media is the capacity to grant all children equitable access, participation, and inclusivity in all learning areas, regardless of location or socioeconomic status. According to Sobel (2019) issues that were of great concern in their discussions were: physical and psychological impact, applications and devices must be safe for use; appropriateness of medium, what and why of using immersive applications for learning; content suitability, need to involve children during design and creation of content; the role of adults, latter influence how children interact with immersive media, particularly teachers who are responsible for integration in classrooms; design, development, and distribution process, before allowing children to use it is important to test for safety and effectiveness. Sobel (2019) observations point at an urgent need for rigorous research on the inherent affordances of IVR educational tools and their impact on young learners. In the short-term, educators must take precautions and rely on developers' health and safety guidelines, including existing studies on children’s cognitive development, to enable them to make informed decisions.

The Arizona State University convention on the impact of immersive media on children recognized a need for regulation and formalization of the industry, with an oversight role by the Federal Communications Commission (FCC) to ensure safe use (Sobel, 2019).

Another notable contribution of the meet is the establishment of data protection for minors using immersive media by updating the Children's Online Privacy Protection Act (COPPA) to reflect on the same. Lastly, participants raised the issue of enacting a guideline to regulate advertising within immersive media environments (Sobel, 2019). These measures aimed at protecting children inform educators that implementation of IVR in classrooms must also be based on children's cognitive development, other than solely understanding the affordances of these applications and their modes of social interaction (Southgate, 2018).

Black (2017) explored virtual reality in K-12 history education and while acknowledging the benefits of these applications identified ethical challenges. Though virtual reality is effective in arousing empathy, there is a risk of going overboard and subjecting users to dark and traumatic events, and this impacts negatively. Virtual reality as a powerful learning tool must be designed with accountability and sound pedagogical to avoid manipulation and trivialization of experiences (Black, 2017).

IVR for education is today an acceptable teaching and learning modality. Leading tech firms are investing heavily in IVR, and it is projected that the industry will experience unprecedented exponential growth in the short-term. The emergence of affordable, accessible, and functional low-cost devices has eased adoption in educational settings. Various literature has identified the potential learning affordances of IVR tools, though there is an absence of a clear framework for evaluating and selecting these tools for implementation in classrooms. Other than pedagogical considerations, there are issues of health and safety, particularly for young users. The intended qualitative content analysis seeks to explore affordances of IVR educational tools and provide educators with an informed framework for implementation in classrooms.

Evaluation Plan: Content Analysis to Identify IVR Affordances

The proliferation of IVR tools for education has seen a rise in literature exploring the intrinsic affordances of these applications. Qualitative content analysis in its nature systematically transforms volumes of text into well organized and succinct summaries of important results (Erlingsson & Brysiewicz, 2017). Content analysis research is effective in analyzing theoretical issues found in the existing literature on IVR educational tools, helping us understand human conditions in diverse contexts of perceived situations. The research questions determine samples to be chosen; subsequently, the text is coded into manageable content categories. The coding process is a selective reduction, and categories consist of phrases, themes, or sets of words that enable the researcher to focus on guided by the research question. In choosing qualitative content analysis, the objective is to develop a rubric from the results and identify explicit pedagogical affordances that improve teaching and learning within the virtual environment. The research approach is logical and objective for identifying and evaluating IVR tools for education to allow for effective integration in classrooms. This is due to the fact that research findings are credible and transferable.

Data Collection Procedures and Measurement Strategies

The population used during data collection will be public content describing affordances of IVR educational tools found online and published within the last five years. The sample will be restricted to low-cost IVR tools explicitly used for educational purposes. Content analysis is applicable to multiple written texts, notwithstanding the source – journals, interviews, survey questions, or existing documents.

To ensure trustworthiness of the content analysis, the data collection approach will be based on the following research questions: What affordances enhance conceptualization of abstract concepts? How do IVR tools facilitate instruction? How are IVR tools aligned to experiential learning theory? In inductive reasoning, the text is analyzed,

and the researcher maintains an open mind as a way of discovering meaningful subjects for answering research questions.

Inductive content analysis for archived peer-reviewed articles involves organizing the qualitative data through:

Open coding, writing notes, and headings while reading the text – Research Question 1: What affordances enhance conceptualization of abstract concepts? Example; *simulated virtual environment, HMD, and experiential learning theory,* or *use of VR in education.*

Reading written material multiple times with additional headings noted in the margins – Research Question 1: What affordances enhance conceptualization of abstract concepts? Example; *presence, motivating* or *engaging.*

Transferring headings to coded sheets and generating categories – Research Question 1: What affordances enhance conceptualization of abstract concepts? For example, *improved understanding, experiential learning,* or *collaborative learning.*

Research Constructs – The study's inductive content analysis will involve preparation, organization, and reporting of results. Examples of constructs to be measured are; *experiential learning* and *pedagogical features.* Trustworthiness in qualitative content analysis ensures the inquiry findings are "worth the while." In inductive content analysis, trustworthiness is required as categories are derived from raw data in the absence of a theory-based categorization matrix.

Trustworthiness in Research Preparation

Data Collection Method – The credibility of qualitative content analysis is dependent on selecting an appropriate method for collecting data. A researcher's self-awareness is important for ensuring credibility, and pre-interviews are an appropriate approach to establish

whether the proposed research questions will provide rich data. The research questions will define the scope and keywords for searching archived peer-reviewed articles in the relevant digital libraries. The Northcentral University Library and ProQuest are rich repositories and provide a large selection of publications. The database search will narrow down through the following keywords; IVR in education, VR affordances, low-cost or low budget IVR educational tools, HMD VR, and pedagogy of IVR educational tools.

Sampling Strategy – Trustworthiness of the findings relies on an appropriate and effective sampling method, criteria for recruiting participants and their knowledge, and how well the data is saturated. For this study, purposive sampling is appropriate for both forms of data collection – semi-structured interviews and archived articles. Purposive sampling for archived articles will rely on the earlier listed keywords. Purposive sampling for semi-structured interviews will focus on educators using IVR educational tools to facilitate learning and teaching, who can provide in-depth and detailed information about these transformative tools. Dependability is based on the stability of data through time and its relevance in different conditions. In qualitative research, there are no clear guidelines for optimal samples; the latter depends on the purpose of the study, research questions, and the amount of data (Erlingsson & Brysiewicz, 2017). As such, purposive sampling will ensure the research collects relevant and rich data that reveals conceptual relationships.

Organizational Phase – Qualitative research retains an advantage due to its richness of the collected data that is further coded and categorized in a reliable and valid way. In the organizational phase, the categories must be well-defined to further enhance the trustworthiness of the study. In the proposed study, categories can include; *improved understanding, realistic environments, sense of presence, experiential learning*, or *collaborative learning.* From the categories, it is important to note the condensed meanings are aligned to the research questions and rooted in the data source. The trustworthiness of the

intended study will depend on rechecking the data multiple times to ensure interpretations remain true to the source and identified features.

Reporting Phase – In qualitative content analysis, reporting results are associated with credibility, transferability, and dependability. Reporting should be systematic and logical, with specifics on how connections between data and results are represented. Poor analysis can create problems when reporting results. The analysis process defines the research phenomenon and brings to the fore new knowledge. Reporting results will be based on the three research questions: *What affordances enhance conceptualization of abstract concepts? How do IVR tools facilitate instruction? How are IVR tools aligned to experiential learning theory?* Additionally, trustworthiness requires that reported results can be successfully transferred to another context. Trustworthiness of results also demands that findings must reflect the participant's voice – conformability – and not subjects of the researcher's biases.

The trustworthiness of the results will rely on an accurate description of the analysis. The relation between results and original data will enable readers to find meaning, and this can indicate trustworthiness. The dependability of the proposed study will remain high if another scholar can follow the decision path taken to eventually find meanings.

Research Participants and Research Ethics

An ethical attitude is a prerequisite for the research project, and the researcher must incorporate respect, empathy, and tact towards the selected participants during the entire process. Semi-structured interviews require participants to share personal and sensitive information. The research must not infringe on personal spaces of participants due to the power imbalance created during the interview. Additionally, the research must protect information provided and adequately prepare participants by informing them of the purpose

and format of study. This is to ensure a reduced risk of exploitation (DeJonckheere & Vaughn, 2019).

Semi-structured Interviews – Selecting an appropriate sample size is vital for the study's trustworthiness. In content analysis design, there is no definitive sample size; for this study, an ideal number would be 30 teachers. The participants will be teachers from across the state involved in using IVR educational tools to facilitate learning. In semi-structured interviews, the researcher collects open-ended data as a way of understanding the participant's feelings, thoughts, and beliefs about a particular phenomenon (DeJonckheere & Vaughn, 2019). This approach also allows for the collection of new, exploratory data correlated to a study topic, and validation of findings through feedback about research results. Example of open-ended questions; *How would you describe student response to the use of IVR tools in your course design? What features in IVR tools are effective in delivering positive outcomes? How do you measure the effectiveness of IVR tools in the classroom?*

Recommendations

More virtual reality applications are rapidly appearing in the market every day and have been accepted as a new modality for instruction and learning. Leading tech firms have invested heavily in improving the affordances of IVR tools for education. However, educators still face challenges, understanding which applications are best suited for specific learning outcomes, and how to align these applications with different course designs (Johnstone et al., 2018). The proliferation of low-cost IVR experiences is enabling a transformation of traditional learning and teaching approaches to meet the needs of modern-day students.

It is incumbent for educational researchers to identify affordances of IVR tools that provide students with meaningful learning experiences and facilitate teaching. Learner engagement is a challenge within K-12 educational settings, and there is a convergence of

thought on opportunities provided for by IVR tools. Educators often find it difficult to identify simple, straightforward tools that are pedagogically relevant for specific subject areas. Educational leaders have in the past used various models to select, adopt, and evaluate technology for classrooms. IVR is a recent phenomenon, and there is an absence of a definitive framework that assists instructors in identifying appropriate tools for implementation.

The capstone project leverages content analysis methodology to add to literature attempting to bridge the gap between technology and pedagogy concerning IVR tools for education. Qualitative research approach identifies themes within the text. The objective of the proposed research is to identify affordances of IVR educational tools for implementation in classrooms. Results of the inductive qualitative content analysis can be useful for developing a framework, the basis for evaluating IVR tool implementation. IVR designers can also use the information to understand how educators evaluate and assess IVR applications for educational purposes.

This paper recommends creation of *Rubric for IVR Tool Evaluation* from the results of the qualitative content analysis study. Contemporary students as *digital natives*, inclined to experiential learning, latter have been found to thrive in technologically supported learning environments (Hu-Au & Lee, 2017). As mentioned earlier, most IVR tools are based on experiential learning theory. Even though technology is evolving, it is assumed these applications will retain their experiential learning features moving into the future.

Kolb & Kolb (2018) four-part cycle of experiential learning based on; experiencing, reflecting, thinking, and acting, is an adaptable model that provides educators with an effective learning alternative, away from the traditional information transmission model. The educational shift towards experiential learning informs on the need to evaluate IVR tools based on affordances that are aligned to Kolb & Kolb (2018) experiential learning model.

A *Rubric for IVR Tool Evaluation* derived from the results of content analysis study can provide instructors with a framework for use on ad hoc basis and evidence-based decision making before implementation. The intended rubric allows instructors to independently evaluate affordances of IVR educational tools, assess suitability according to learner needs, and identify expected learning outcomes, within the context of the classroom.

Conclusion

IVR is the new transformative learning modality, and educational researchers are exploring methods of including this technology in the classroom. The emergence of low-cost virtual experiences powered through smartphones has increased accessibility enabling cash strapped educational ease of adaption in classrooms (Jowallah et al., 2018). The prevalent challenge for educators is identifying affordances that provide learners meaningful learning experiences that are aligned to specific curriculum. Various literature explores the pedagogical affordances of IVR tools, but educators lack a comprehensive framework to evaluate the suitability of these applications for implementation (Johnston et al., 2017). The capstone project intends to add on literature attempting to find a balance between technology and pedagogy concerning IVR tools for education. A content analysis study to explore affordances of IVR educational tools will be the basis for creating an evaluation framework that will support instructors in assessing and selecting tools for implementation.

Despite convergence of thought on advantages of virtual reality for K-12 curriculum, several limitations still exist:

Possible ethics, health, and safety issues; high fidelity IVR can appear real to young users raising concerns about exposing these learners to the virtual environment. Additionally, there is a lack of clear privacy policies and protection of user data. More research is needed to establish how these IVR tools affect user health and safety, particularly young children

New digital divide; though low-cost IVR tools have increased accessibility, they still require Internet connectivity, and this might limit access for vulnerable communities. Educators also need to understand these applications can not entirely replace real-world experiences.

Researchers need to further explore these revolutionary learning modalities and recognize that technology can never replace physical encounters.

References

Babich, N. (2019). How VR In Education Will Change How We Learn And Teach. Retrieved from https://xd.adobe.com/ideas/principles/emerging-technology/virtual-reality-will-change-learn-teach/

Bailey, O. J., & Bailenson, N. J. (2017). Immersive Virtual Reality and the Developing Child. Retrieved from https://vhil.stanford.edu/mm/2017/07/bailey-ivr-developing-child.pdf

Black, R. E. (2017). Learning Then and There: An Exploration of Virtual Reality in K-12 History Education. Retrieved from https://repositories.lib.utexas.edu/handle/2152/63616

Bonasio, A. (2019). Immersive Experiences in Education New Places and Spaces for Learning. Retrieved from https://edudownloads.azureedge.net/msdownloads/MicrosoftEducation_Immersive_Experiences_Education_2019.pdf

Bower, M. & Sturman, D. (2015). What are the educational affordances of wearable technologies? Retrieved from http://dx.doi.org/10.1016/j.compedu.2015.07.013

Brown, A., & Green, T. (2016). Virtual Reality: Low-Cost Tools and Resources for the Classroom. TechTrends: Linking Research & Practice to Improve Learning, 60(5), 517–519. https://doi-org.proxy1.ncu.edu/10.1007/s11528-016-0102-z

DeJonckheere M., & Vaughn, L. M. (2019). Semi structured interviewing in primary care research: a balance of relationship and rigour. Retrieved from http://fmch.bmj.com/

Domingo, J. R., & Bradley, E. G. (2018). Education Student Perceptions of Virtual Reality as a Learning Tool. Journal of Educational Technology Systems, 46(3), 329–342. https://doi.org/10.1177/0047239517736873

Erlingsson, C. & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. Retrieved from https://www.sciencedirect.com/science/article/pii/S2211419X17300423

Evans, A. (2018). Pros and cons of virtual reality in the classroom. The Chronicle of Higher Education, Retrieved from http://search.proquest.com.proxy1.ncu.edu/docview/2038287339?accountid=28180

Häkkilä, J. Colley, A., Väyrynen, J., & Yliharju, A. (2018). Introducing Virtual Reality Technologies to Design Education. Retrieved from https://journals.hioa.no/index.php/seminar/article/view/2584

Hu-Au, E., & Lee, J. (2017). Virtual reality in education: a tool for learning in the experience age. Retrieved from https://www.researchgate.net/publication/324704089_Virtual_reality_in_education_a_tool_for_learning_in_the_experience_age

Johnston, E., Olivas, G., Steele, P., Smith, C., & Bailey, L. (2018). Exploring Pedagogical Foundations of Existing Virtual Reality Educational Applications: A Content Analysis Study. Journal of Educational Technology Systems, 46(4), 414–439. https://doi.org/10.1177/0047239517745560

Johnson-Glenberg, M. C. (2018). Immersive VR and Education: Embodied Design Principles That Include Gesture and Hand Controls. Retrieved from doi: 10.3389/frobt.2018.00081

Jowallah, R., Bennett, L., & Bastedo, K. (2018). Leveraging the Affordances of Virtual Reality Systems Within K–12 Education. Retrieved from https://nsuworks.nova.edu/fdla-journal/vol3/iss1/7/

Kaminska, D., Sapinski, T., Wiak, S., Tikk, T., Haamer, E. R., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual Reality and Its Applications in Education: Survey. Retrieved from https://www.mdpi.com/2078-2489/10/10/318/htm

Kolb, A., & Kolb, D. (2018). Eight important things to know about The Experiential Learning Cycle. Retrieved from https://www.researchgate.net/publication/330993292

Leung, T., Zulkerine, F., & Isah, H. (2019). The use of Virtual Reality in Enhancing Interdisciplinary Research and Education. Retrieved from https://arxiv.org/ftp/arxiv/papers/1809/1809.08585.pdf

Markowitz, D. M, Laha R., Perone, B. P., Pea, R. D. & Bailenson, J. N. (2018). Immersive Virtual Reality Field Trips Facilitate Learning About Climate Change. Retrieved from doi: 10.3389/fpsyg.2018.02364

Martín-Gutiérrez, J., Mora, E. C., Añorbe-Díaz, B., & González-Marrero, A. (2016). Virtual Technologies Trends in Education. Retrieved from https://www.ejmste.com/article/virtual-technologies-trends-in-education-4674

Minocha, S., Tudor, A., & Tilling, S. (2017). Affordances of Mobile Virtual Reality and their Role in Learning and Teaching. Retrieved from https://dl.acm.org/doi/10.14236/ewic/HCI2017.44

Parong, J. & Mayer, E. R. (2018). Learning Science in Immersive Virtual Reality. Retrieved from http://dx.doi.org/10.1037/edu0000241

Radianti, J., Majchrzak, A. T., Fromm, J., & Wohlgenannt, I. (2019). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Retrieved from https://doi.org/10.1016/j.compedu.2019.103778

Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., McGuire, J. & Smithers, K. (2018). Artificial intelligence and emerging technologies (virtual, augmented and mixed reality) in schools: A research report. Retrieved from https://docs-edu.govcms.gov.au/system/files/doc/other/aiet_final_report_august_2019.pdf

Sobel, K. (2019). Immersive media and child development: Synthesis of a cross-sectoral meeting on virtual, augmented, and mixed reality and young children. Retrieved from https://joanganzcooneycenter.org/wp-content/uploads/2019/05/jgcc_immersive_media_and_child_development.pdf

Templeton, E. C. (2019). An Analysis of Pedagogical Affordances of a Virtual Reality Learning Environment in a Catholic School. Retrieved from https://scholarworks.moreheadstate.edu/cgi/viewcontent.cgi?article=1341&context=msu_theses_dissertations

Velev, D. & Zlateva, V. P. (2017). Virtual Reality Challenges in Education and Training. Retrieved from https://www.researchgate.net/publication/312213416