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Design Strategies for User Interfaces in Virtual Reality Environments

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
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Walden University
2020

Abstract

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MS, Walden University, 2018

BS, Capella University, 2015

Doctoral Study Submitted in Partial Fulfillment

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Abstract

The virtual reality market is rapidly increasing and is projected to drastically expand soon as more head-mounted displays are released to customers. These changes have made it more critical that organizations have adequate user interface strategies. Yet there is still a lack of research on how to design quality virtual reality user interfaces that result in positive user experiences. The purpose of this qualitative multiple-case study was to identify design strategies software developers use to create user interfaces for virtual reality environments. Constructionist and constructivist theories served as the conceptual frameworks. The participants consisted of 6 developers from 3 different organizations in Texas who had experience with designing virtual reality environments. Data collection involved interviews with 6 software developers. Member checking was used to ensure the accuracy of the findings captured from participants. Thematic analysis yielded 5 key themes: focusing on a simple design, following an iterative approach during development, satisfying the customer and stakeholder, delivering prototypes and models throughout the design and development process, and receiving feedback throughout the process. Findings may benefit future software developers as they form strategies for creating successful virtual reality user interfaces. Implications for positive social change include potentially implementing virtual reality user interfaces for the public that are simple and easy to use, and that do not cause physical discomfort.

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Dedication

I would like to dedicate this doctoral study to my family and closest friends for believing in me and helping me remain focused during this journey. Even though they did not understand the amount of time needed for me to finish assignments and complete the program, they showed their support from the very start. Their support and encouragement has meant so much to me, especially during the times when I was tired, frustrated, or discouraged. They constantly praised me for having the drive and will to accomplish my goals and encouraged me to continue on the journey and never give up.

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The process of writing this doctoral study has been an exciting yet challenging experience. I am appreciative for the people around me who were supportive and who inspired me throughout this journey.

I want to express my sincere appreciation to my committee chair, Dr. Robert Duhainy, for his invaluable feedback and continuous support throughout my doctoral study journey. It has been a true blessing to have him as my chair. I would not have accomplished this much without his guidance. He provided direction, not only on the approach for conducting research, but he also guided me on how to become a scholarly researcher. His consistent mentorship and methods for fostering motivation contributed to my successful completion of the doctoral study. I want to thank my committee members, Dr. Gary Griffith and Dr. Steven Case, for always providing valuable feedback. Their constructive reviews helped me make the changes needed to transform my doctoral study into something great.

I would also like to sincerely thank the participants involved in the research who took time out of their business schedules to contribute to the research.

Finally, I would like to extend a huge thank you to my family and closest friends for their nonstop support and encouragement.

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Section 1: Foundation of the Study

Background of the Problem

Virtual reality environments are becoming more popular. As such, understanding how this technology can help with rudimentary learning is important. A true virtual reality platform provides a mock world that combines elements of an artificial and real world together to create an immersive experience for a user (Gammack & Hodkinson, 2003). Virtual reality environments have user interfaces that produce innovative ways to discover information through learning (Day, 2015). When designing a learning environment based on virtual reality, it is necessary to consider a range of complex thoughts and ideas. Poorly planned and executed applications may not motivate and support users' learning regardless of how advanced or interactive the virtual reality user interface is.

Regardless of how much the interest in this area has grown, some IT software developers still experience challenges when attempting to design virtual reality user interfaces for training applications. Outside of the more apparent limitations of technical know-how and budget, most IT software developers do not have a solid understanding of the design considerations necessary when planning to implement a virtual reality system. The key is to consider the issues that beginner developers face, not only to provide a guide they can use when they begin to consider the implementation of a virtual reality user interface, but to also inform others about challenges they may encounter in developing such interfaces. Sharing such information could lead to best design practices that fully realize the potential of immersive technologies (Grandi, 2017).

Problem Statement

Virtual reality implementations have negatively impacted a number of organizations, and this is due to lack of user interface strategies (Rubio-Tamayo, Barrio, & García, 2017). Forty percent of IT software developers reported having a below average or average understanding of the virtual reality development process (Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017). The general IT problem is that many organizations implement virtual reality environments but do not realize that there are other factors related to usability that deserve consideration when designing a virtual reality environment. The specific IT problem is that some IT software developers lack design strategies to improve the quality of virtual reality environment user interfaces.

Purpose Statement

The purpose of this qualitative multiple-case study was to explore design strategies used by IT software developers to improve the quality of virtual reality environment user interfaces. The target population included IT software developers in organizations around the San Antonio, Texas, area, who were selected because they had design strategies to improve the quality of virtual reality environment user interfaces. The impact that this study could have on social change includes increasing designers' understanding of ways to implement virtual reality user interfaces that are simpler and easier for the public to use.

Nature of the Study

The main methodologies used in academic research are qualitative, quantitative, and mixed methods. An in-depth understanding of each research methodology was key in determining which one to use. Researchers use the qualitative method to analyze and produce a comprehensive understanding of an issue or event (McCusker & Gunaydin, 2015). I decided to use this method because I concluded that it would help me collect detailed information about different design strategies and understand how IT software developers used them for improving the quality of virtual reality environment user interfaces. The quantitative method is used to analyze and clarify relationships between elements of an issue by utilizing variables (Szyjka, 2012). This type of method has the benefit of more straightforward analysis and may demonstrate how independent variables related to virtual reality affect the dependent variables, but because this study was explorative, a quantitative study was not appropriate to fully address the topic. The mixed-methods approach involves the use of both qualitative and quantitative methods in one study or multiple studies when investigating an issue or attempting to answer research questions (McKim, 2017). Mixed-methods studies require expertise in both qualitative and quantitative methods and may require substantially more time than either method alone. For this reason, I decided that mixed methods were not appropriate for this study.

Some of the qualitative designs that are used frequently are ethnography, phenomenology, and case study (McCusker & Gunaydin, 2015). The key is for the researcher to choose a qualitative research design that will answer their research question

the best. Ethnographies are used to examine different cultural groups to understand more about what is behind their activities and behaviors as it pertains to an issue (Wall, 2015). This design would not have been an appropriate choice for this research as I did not focus on cultural groups or cultures. Koopman (2015) explained that the phenomenology research approach is used to recognize and describe participants' lived experiences in order to understand an issue. The phenomenological approach was not appropriate for this study because answering the research question did not require lengthy interaction with the participants. Elman, Gerring, and Mahoney (2016) defined a case study as an observed analysis that is undertaken to investigate a current issue that has realistic context when the limits between an issue and its context are not obvious. I chose a case study design, specifically a multiple-case study, because I wanted to examine the research study within a specific context or setting.

Research Question

What design strategies are used by IT software developers to improve the quality of the virtual reality environment's user interface?

Interview Questions

1. What design strategies have you used to develop virtual reality environment user interfaces?
2. How does culture of users impact your design strategies to develop virtual reality environment user interfaces?
3. How does the knowledge level of users impact your design strategies for developing virtual reality environment user interfaces?

4. How do you effectively handle skill level differences to develop quality virtual reality environment user interfaces?
5. How do you create environments that are expressive and allow users to interact with the environment in meaningful ways?
6. How do you promote discovery and exploration during the virtual reality session?
7. What aspects of your design strategies contributed to a user-friendly interface for users?
8. What aspects of your design strategies ensure that the virtual reality environment user interfaces you develop will be acceptable by users?
9. What design process do you employ to ensure the virtual reality environment user interfaces are easy to use?
10. What challenges did you face when developing and implementing the strategies for designing user interfaces for virtual reality environments?
11. How did you address the challenges of developing and implementing the strategies for designing user interfaces for virtual reality environments?
12. How do you work with others in the organization to ensure there is one acceptable and coherent virtual reality environment user interface?
13. How do you receive feedback as to whether or not your design is acceptable by users and easy-to-use?
14. Summarize or identify design strategies you use to develop virtual reality environment user interfaces that will cater to the majority of users.

Conceptual Framework

I used a constructionist learning theory to anchor this multiple case study. John Dewey and Jean Piaget were the theorists who developed a comprehensible conception of constructivist theory (Seltzer, 1977). The constructivist theory states that knowledge is gained from how a person interacts with an environment and places emphasis on the mixture of current knowledge, input from senses, and new information to create a newfound understanding and meaning via true, active, supportive, and insightful learning activities (Huang, Rauch, & Liaw, 2010). A limitation of Piaget's theory of constructivism is its tendency to miss how media and how a person's style or preference contributes to learning and development. Seymour Papert's constructionism theory focused on how people gained more knowledge when they were involved and immersed in the activities (Bruckman & Resnick, 1995). Papert was one of Piaget's students and found that people would be more involved in learning if they were creating something that someone else would see and maybe use (Tocháček, Lapeš, & Fuglík, 2016). Furthermore, people would make every effort to solve problems and learn when they encountered complex issues because they would be motivated by what is being constructed (Talja, Tuominen, & Savolainen, 2005). Bruckman and Resnick (1995) shared the same idea that constructionism is the notion that people develop new knowledge that has a certain usefulness when they are involved in creating things that mean something to them.

Constructionism as a conceptual framework was applicable to this research because a constructionist learning environment has the potential to succeed with respect

to attaining learning goals by allowing construction and unrestricted exploration. Within virtual reality learning environments, users can interact with objects and content as if they were in the real world, and this is a key characteristic in constructionist theory because users take an active role in seeking knowledge (Howard, Ellis, & Rasmussen, 2004). The design strategies for virtual reality environments align well with the principles of constructivism and constructionism. The first principle that helps guide IT software developers in creating successful environments is that the environment has to contain construction tools that are expressive and allows users to interact with the environment in meaningful ways (Kafai & Burke, 2015). The second principle is that the goals and construction tools within the environment should promote discovery and exploration during the session (Kafai & Burke, 2015).

Definition of Terms

Immersive technologies are interactive and perceptual technologies that distort the line between simulated and physical worlds (Rubio-Tamayo, Barrio, & García, 2017).

User interface is a set of tools and techniques that a user can interact with to move around an environment (Shneiderman, 2000).

Virtual environment is a user-centered, interactive, 3D computer-generated environment that allows users to complete a variety of tasks to convince them that they are immersed in an artificial world (McCorkle & Bryden, 2007).

Virtual reality is when someone is “surrounded by a three-dimensional computer-generated representation, and is able to move around in the virtual world and see it from

different angles, to reach into it, grab it, and reshape it" (Cruz-Neira, Sandin, & DeFanti, 1993, p. 135).

Assumptions, Limitations, and Delimitations

A number of external or internal influences can impact research and results. Identifying and recording these factors is part of building credibility. The types of influences that transpire in research are assumptions, limitations, and delimitations.

Assumptions

Assumptions are an important part in research studies because they are essential for enabling and steering the study. Every so often, there are influential factors in the research that are assumed to be true but not proven due to the lack of data (Rule & John, 2015). There were multiple assumptions in this study. The first assumption was that my research would provide enough data to address the main research question. I assumed that the software developers who participated in the study would reply to questions honestly. I also assumed that the software developers would be willing to provide sufficient information. Finally, I assumed that choosing an interview data collection method over a survey or questionnaire would not affect or deter the outcomes.

Limitations

Limitations are components within a research design that are basically beyond a researcher's control but could affect the outcome of the study (Dasgupta, 2015). All studies, regardless of how well they are written and conducted, have limitations. For example, a researcher may only have access to specific data and a specific group of individuals within an organization. The main limitations in this study came from the use

of the qualitative method. Researcher bias was another possible limitation. Also, the interviews were limited to the amount of time participants had available to participate. Another limitation was that the participant count was limited to how many software developers were working on virtual reality design in the study organizations.

Delimitations

Delimitations in a study are those aspects that emerge from scope limitations within the study and from the decisions consciously made by the researcher while developing the study. A researcher imposes these boundaries on a study in order to control or limit the scope (Yazan, 2015). There were several delimitations in this study. The first was that I only considered organizations whose staff design and create software. Second, I only considered organizations that employed individuals in the role of software developer. Third, only organizations that met the previous conditions and were located around the San Antonio, Texas,area were considered. Another delimitation was that the software developers in the study had to have experience with building virtual reality learning environments.

Significance of the Study

Contribution to Information Technology Practice

Some IT software developers fail to notice when their virtual reality user interface has usability issues within their applications (Goktas, Coban, Karakus, Karaman, & Gunay, 2015). This study may be valuable to IT software developers because it presents design strategies for virtual reality applications. The findings may provide IT software developers with a strong framework for evaluating virtual reality user interfaces.

The findings in this study may also contribute to the improvement of the IT practice by adding to the literature on virtual reality environments and the design strategies used to develop the user interfaces, thereby increasing the understanding of the multifaceted nature of this topic. The objective of this study was to produce a design model for IT software developers that would benefit them whenever they attempted to use a combination of strategies in their applications. With a framework prepared, IT software developers could more precisely combine strategies to improve the usability of the virtual reality user interfaces within applications.

Implications for Social Change

The implications for social change include increasing understanding of the problems and concepts experienced in a virtual reality environment. The literature reviewed for this research suggests that virtual reality environment design efforts have mostly been focused on developing visual quality and efficiency. Poorly designed user interface components in virtual reality environments affect usability (Gabbard, Hix, & Swan, 1999). There are several captivating virtual reality environments that are hard to use and therefore not productive. Even though virtual reality environments may serve as good applications for entertainment, usability issues keep them from being helpful for handling real-life problems efficiently (Gabbard et al., 1999). The power that virtual reality has is how it can immerse a thought into a virtual world. These worlds play on peoples' senses, and their senses influence the way they feel, think, and understand things around them, and could impact major decisions. Virtual reality is a communication tool

that can influence a person's important decisions for humankind ("How Will Virtual Reality Change Our Lives?," 2016).

A Review of the Professional and Academic Literature

The literature review offers a summary of the literature found on the topic of virtual reality environments. The literature review also played an essential part in answering the main research question and exploring the strategies IT software developers need to improve the quality of virtual reality environment user interfaces. In reviewing the literature, I studied factors in the virtual reality industry that have an impact on strategies that software developers use when developing virtual reality environment user interfaces. The intent of this review was to evaluate existing research with the purpose of investigating the strategies software developers use during the design and development process to create virtual reality environment user interfaces. In the literature review, I break down the information collected and offer a summary of the sources. I also provide a conceptual foundation section that addresses models and theories typically used in instructional design and virtual reality. In the last section of this literature review, the virtual reality industry and the need for skillfully constructed designs to produce successful virtual reality user interfaces are discussed. Constructionism and constructivism formed the conceptual framework for exploring why new virtual reality user interfaces might not be easy to design for developers.

I used different sources of professional and academic articles to ensure I fully covered the study topic. I used ProQuest Central, IEEE Computer Society Digital Library, Google Scholar, ACM Digital Library, Science Direct, Sage Premier,

EBSCOhost, and IEEE Explore for the main database searches. I also used the lists of references that were included in the articles I found as alternate sources for my study. As I searched, I looked at and thought about articles from different periods of time, concentrating on more recent articles (2014 and newer) to make sure that I had a current view of the issues. The method I used for searching progressed with time, starting with specific search conditions for the different themes in the literature review. For constructionism, search key words changed to consist of the following: *constructionist theory*, *constructionism philosophy*, and *constructionist learning*. For virtual reality user interface development, search key words changed to consist of the following: *virtual reality user interface issues*, *virtual reality user interface problems*, *quality of virtual reality user interfaces*, and *user interfaces in virtual reality environments*. The literature found for both constructionism and virtual reality user interface development justified the use of a case study as the research design. I found a wide range of peer-reviewed resources that were published within the 5-year time frame requirement. Altogether, I included 157 articles in the literature review with 96% published between 2014 and 2019 and 95% peer-reviewed sources.

Conceptual Framework

One of the core issues with virtual reality being used as a tool for learning is that many models or theories do not exist that will help justify the development of an application. In this subsection, I explain the constructionist theory and its concepts. I also reveal how some researchers have used the constructionist/constructivist theory or other models to assist them with creating products. The goal is to design virtual environments

capable of exemplifying what is being taught. I expand on how the technical capacities of virtual reality align with the principles of constructionist and constructivist learning.

Constructionism is a well-recognized theory for learning and design today, and it involves a couple of forms of construction. First, as a learning theory constructionism emphasizes that the process of learning is an active one where individuals actively obtain knowledge from the experiences they have in this world. Constructionism was based on top of Piaget's constructivist theory and included the notion that individuals gain new knowledge when they actually participate in constructing things that mean something to them personally. The important thing to note is that the individuals are engaged in the creation of something that means something to them and the people around them. Papert developed the constructionist theory, which he defined as emphasizing discovery learning where users are inspired to work with physical items in the real world and utilize their existing knowledge to obtain more knowledge, according to Formosa, Morrison, Hill, and Stone (2017). Papert emphasized that learning occurred when users participated in constructing objects that meant something to them (Formosa et al., 2017). Formosa et al. added that Papert created the constructionist theory based on Piaget's constructivist theory. It is generally known in the educational field that an important part of the learning process involves hands-on construction. Constructionism as a theory for design has been used in different contexts such as designing constructionist-minded interventions in instruction and designing new constructionist media that involves various levels of skill. Constructionism has also been utilized as a way of looking at learning as a design

process. Papert's constructionist model was thus a suitable conceptual framework for understanding the strategies for developing virtual reality user interfaces.

Researchers have made many different justifications for why interaction in virtual reality worlds might increase how motivated users are. Xu and Ke (2016) and Formosa et al. (2017) stated that constructionism offers the notion that knowledge can be constructed through physically interacting with the real world. Lindgren, Tscholl, Wang, and Johnson (2016) stated that since real-world scenarios can be set up in virtual reality, users could learn when they are placed in the context where their learning should be applied. As explained by Green et al. (2014), being placed in the virtual environment allows experiences in knowledge construction such as altering the virtual world and proportions of objects in order to have access to newer viewpoints. Hack (2015) asserted that using the constructionist view allowed data that are not usually observable or available in the real-world to be converted into observable information that could highly influence learning and education. Lindgren et al. (2016) stated that by physically exploring an environment it could improve user attitudes that result in new knowledge, which is an essential principle of the constructionist learning theory. Formosa et al. and Cochrane et al. (2017) asserted that users learn more from participating in meaningful activities that are relevant to them. Lee et al. (2017) and Lu and Davis (2018) agreed with this assertation.

Furthermore, Cohen, Jones, Smith, and Calandra, (2017) recognized that trainers have implemented several constructionist approaches for educating and that there is a need for hands-on experience within the environment. Tartaro, Cassell, Ratz, Lira, and

Nanclares-Nogués (2014) and Buckingham (2015) asserted that such approaches stress the idea that knowledge is not just transferred by an instructor; rather, users should feel and experience new things in order to make sense of them. As Cochrane et al. (2017), Green et al. (2014), and Lindgren et al. (2016) noted, constructionist approaches to training and education, including learning by doing and working on simulations, have long been viewed as significantly benefiting user learning. Formosa et al. (2017) stated that the effectiveness of these methods is associated with the users' new motivation and perspectives as they pertain to learning new material, confidence in how well they understand theoretical concepts, self-reflection, and academic performance. In the real world, users learn how to do things, but in a virtual environment they learn how to think about how to do those things in order to observe the effects of their changes.

Analysis of the conceptual framework. Computers may effectively reduce complex representations into simple representations that are easier to understand. Virtual reality environments, mainly their objects and rooms because they are always being created and recreated by users, are examples of constructionist ideas applied to virtual reality design. Constructionism incorporated a couple of forms of construction. First was that learning is a process that involves people actively constructing knowledge based on their worldly experiences. Second, constructionism includes the notion that people effectively gain new knowledge when they participate in creating personally meaningful objects (Formosa et al., 2017). This thinking was fundamental to virtual reality design. The constructionist approach put emphasis on learning by actions and allowed users to collaboratively work in valid conditions, follow their own paths to handle issues, and

construct virtual objects as potential solutions. There were a number of researchers who supported the use of the constructionist theory for various reasons. Cochrane et al. (2017) and Park, Le, Pedro, and Lim (2016) stated that this approach also incorporated the problem-based learning principles into the guidelines for setting up a virtual reality world as a learning environment and implemented learning tasks that involved users creating digital objects that echoed their understanding about their knowledge. This constructionist approach to problem-solving was suitable because as Greenwald, Corning, Funk, and Maes (2018) and Kengne et al. (2018) encapsulated, it enables the users to construct from their mental space to the virtual and physical world. Although Greener (2017) and Davis and Moscato (2018) shared that there were no substitutes to real-life activities or interacting with others, Brade et al. (2017) and McMillan, Flood, and Glaeser (2017) stated that a virtual reality environment offers gratifying experiences in learning that are hard to gain otherwise. Deacon, Stockman, and Barthet (2017) added that virtual reality contributed direct manipulation, immersion, and exploration qualities to models. While in the real world, users learn how to do things, but, as Muhanna (2015) mentioned, in a virtual environment they could learn how to think about how to do those things in order to observe the effects of their changes.

Instructors have implemented numerous constructionist approaches to training, recognizing the need for user-centered learning via direct interaction in the virtual class setting, and as stated by Formosa et al. (2017), the approaches emphasize the idea that knowledge cannot just be transferred by the instructor; rather, users have to feel and experience new actions so they make sense. According to Mercado-Doménech, Carrus,

Terán-Álvarez-Del-Rey, and Pirchio (2017), virtual reality supports a constructionist approach to learning because it allows users to interact with the contents in rich detail. Gilbert et al. (2017) explained that the use of the constructionist approach when designing a virtual reality environment accomplishes many things because it seeks to capitalize on users' opportunities for expressing themselves creatively and participating actively. The use of virtual reality in the area of training simulations often promotes more meaningful user interaction, but the simulations are usually not located in a virtual community. According to Kafai and Burke (2015), the use of the constructionist approach began with the thought that average users were more creative and brighter than typically assumed and could accomplish good things if they had a setting that would support it. Xu and Ke (2016) also stated that using a constructionist approach would also offer software tools that were well made and had a high limit for what could be done with them. It also inspired users to create content while maintaining quality by imposing a set of standards.

Principles of constructivism/constructionism. In order to use constructionism and constructivism as a framework for design strategies that IT developers can use when developing virtual reality environment user interfaces, certain principles have to be understood. Constructivism and constructionism are like a serpentine water monster that has many heads, usually determined by the area or industry in which they are used, but each head is connected to one body of thought, with small differences. For instance, in education, as expressed by McKenney, Kali, Markauskaite, and Voogt (2015), the emphasis is on how learning may be more effective when people construct knowledge on their own. With the various ways that constructivism is packaged, it makes it challenging

to unearth the theory's main principles. I will discuss the constructivist and constructionist principles that may be applied to the design of virtual reality environments.

Simplicity was one of the main principles of constructionism and constructivism. Anderson and Stein (1994/2018) and Eytam, Tractinsky, and Lowengart (2017) stated that simplicity is the notion that complexity stems from how small pieces are linked together. So, the little pieces of an item may be described in a simple way and then connected together in an intricate manner. When making interactions, the principle of simplicity is that a beginner developer should know how to simply define different interactions and put them together to produce a stimulating experience. Multiplicity was another principle, and Fitch (2018) stated it was the notion that no one correct truth existed with constructionism and constructivism. Mann and MacLeod (2015) and Kinghorn (2018) also supported the principle of multiplicity. Multiplicity brought forth the idea that there was no single process but numerous means to an end. Although people could very well build their own knowledge and experiences in countless ways, that knowledge and those experiences may still be analyzed and examined from different perspectives utilizing various methods. What makes multiplicity so valuable to developers is that the complexity could be split up and interpreted by concentrating on specific pieces of it. IT Developers must understand issues completely in order to create the interactions within the virtual reality environments so that they were conceptually linked to one another. Different techniques can be used by a developer to help them see that the interactions all relate to the same issue but highlight different parts of it.

Hyperlinks and buttons between different views could assist the IT developer with comparing the interactions. Furthermore, while the interactions occur in a virtual environment, other things could be linked to them, to demonstrate the action movements in every view. Consequently, the developers could then pick up on how the interactions were connected.

Making exploration practical is another principle. In constructionism and constructivism, constructing knowledge and learning are engaging tasks for users. IT developers may make the act of exploring an attractive task, which, in turn, may make learning how to design in virtual reality environments easier. This could be accomplished by focusing on how the environment handles errors. If the IT developer treats the errors like a fundamental part of the process of exploring, the errors may be utilized to make feedback available when it comes to showing what is needed to complete a task. The developers may then make their mistakes and review the outcome to give them a real understanding about what design options are available. This means that errors should be forgiven fairly easily. Personal control is another principle. Actively constructing knowledge is the concept of personal control. Individuals increase control over their own learning processes by actively creating knowledge for themselves. In education, instructors or trainers provide support to help learners. In a virtual reality environment, guidance may be offered using advice, objects, and tutorials that would fade away whenever a learner had finished constructing the skill and knowledge needed to complete the task. The assistance provided to users should be dynamic and tailored to their capabilities. This may be a hard task because virtual reality applications could not

determine the state a user was in. However, different stages of guidance may be offered, like pop-up messages, contextual help, and even tutorials based on area of knowledge.

The reflection process is another principle. Even though actions are important in constructionism and constructivism, constructing knowledge involves reflecting (Amineh & Asl, 2015; Lai & Hwang, 2015) in order to create effective links between chunks of knowledge and an knowing the consequences. The developer may examine their work from various angles and levels (Jamil, Tariq, & Jamil, 2016; Smith, Inoue, Spencer, & Tennant, 2017; Weidner, Nagel, & Weber, 2018). Cremers, Wals, Wesselink, and Mulder (2016) and Lin, Lai, Lai, and Chang (2015) asserted that the iterative process support was another method of fostering reflection because it created a space for developers to reflect on an iteration's output and then they could apply that newer knowledge to the subsequent iteration.

Applying constructivist principles. Constructivism and constructionism principles could be used to create the user interface for a virtual reality environment design. Each module of a virtual reality application could be simple to design and could be easily put together and connected in an intricate way. Therefore, if needed, any piece can be exchanged with another piece where the functionality was somewhat different and could connect to the whole module similarly. A developer can study design tools from various domains and then determine how they were alike and how they were linked to the problem areas. This would make several views of the design process available with differing granular levels; and they all could provide interfaces that allowed direct manipulation since that was typically normal for users as it provided feedback

immediately.

A group of researchers noted that the principles of constructivism were important and were the basis for understanding how learning occurs in virtual reality environments (Gautam, Williams, Terry, Robinson, & Newbill, 2017; Huang & Liaw, 2018; Potkonjak et al., 2016). The principles of constructivism were generally mixed into learning activities that were simulation-based. A virtual reality environment could serve as a chance to integrate constructivist activities into a design process. Mbati and Minnaar (2015) and Toven-Lindsey, Rhoads, and Lozano (2015) both pointed out that some of the aspects of constructivism included intellectual activity in a setting that was built on previous knowledge and then promptly applied through hands-on exercises with self-reflection and feedback. As Huang and Liaw (2018) noted, constructivist learning included exploring and discovering virtual worlds that were already built, and virtual reality technology provided a constructivist learning process that required individuals to study the virtual environment's models and how its features reinforced learning.

Supporting and Contrasting Theories

The experimental and exploratory nature of virtual reality environments lined up well with the constructionism and constructivism learning theories because users actively engaged in the construction of their own knowledge and used digital objects to achieve this. The objective of the design of virtual reality environments was to produce virtual environments for users to like and to motivate them to create meaningful objects that were personal to themselves. Constructivism and constructionism were the main theories guiding this study, but there are other considerations when technology is involved.

Virtual reality technology required the use of other theories and models to outline how applied learning came into play. Some of theories and models that had been considered were the activity theory, the technology acceptance model, the flow theory, and the instructional design model.

Activity theory. In formulating the activity theory, researchers base key tenets on a user's activity and not so much on the content that was presented (Karakus, 2014). This theory has been a framework that has generally been utilized to inform practice and research for mobile learning, yet Cochrane et al. (2017) maintained that it was hard to use and was more appropriate as a tool for analyzing user activity as opposed to a tool for instructive design. An activity consists of numerous processes and actions. Dalsgaard (2017) argued that the activity of the user is centered on an object or goal that could represent the condition of the issue or problem. Additionally, user activities have to be completed so the goal was reached. Through this activity model, one can gain an understanding of how things interact together when a user carries out an action with a specific objective (Karakus, 2014). As it pertains to this study, the activity theory could help clarify how an IT developer could have a balance between users and the learning resources within a virtual reality environment. The key elements--motivation, interaction, direction and guidance, and evaluation--could be designed by looking at their interlocking dynamics (Swist & Kuswara, 2016). Contradictions and tensions could serve as the bases for developing the activity system. A developer would need to think about the aspects of the particular situation to form the design so that, as Karakus, Baydas, Gunay, Coban, and Goktas (2016) asserted, learning is managed effectively. During the

design process, a developer should figure out how to include every aspect of an activity system so the balance between the different components is not disturbed. Figure 1 illustrates a virtual reality environment design using activity theory.

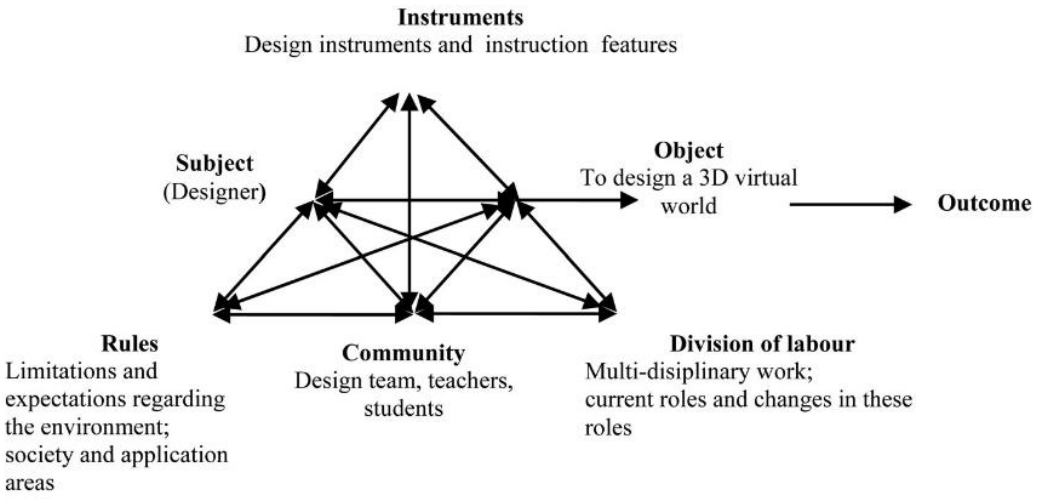

Figure *1*. A Virtual Reality Environment Design Using Activity Theory. Reprinted from "Orchestrating Learning During Implementation of a 3d Virtual World," by T. Karakus, O. Baydas, F. Gunay, M. Coban, and Y. Goktas, 2016, *New Review of Hypermedia and Multimedia, 22,* p. 4. Copyright 2016 by Taylor & Francis Group. Reprinted with permission.

Technology acceptance model (TAM). Theory-based models had helped researchers evaluate users' attitudes as it pertained to virtual reality environments. The goal of Fred Davis's technology acceptance model (TAM) was to analyze user acceptance as it related to information technology (Alharbi & Drew, 2014; Rauniar, Rawski, Yang, & Johnson, 2014). Based on the constructivist method, theories of instruction concentrated on real activities to motivate users. A key factor that impacted

learning performance and boosted users' efficiency and interest in learning was context. Users would take an active role in interacting in their real worlds by applying what they learned to their day-to-day activities, therefore improving the success of learning results (Bower, Howe, McCredie, Robinson, & Grover, 2014; Meredith, 2014). Knowledge should be gained in set learning settings that mirror the actual circumstances under which users are expected to use their new skills and knowledge (Stieler-Hunt & Jones, 2017). Well-made virtual environments allow for the creation of training-type tasks to support activities done in real life (Bier, Ouellet, & Belleville, 2018). Numerous researchers had acknowledged that web-based systems could provide a substitute for actual learning environments (Kurilovas, Kubilinskiene, & Dagiene, 2014). Innovative virtual reality environments could be designed to close the space between the learning from the education and training offered in a traditional class setting and actually applying the knowledge in a virtual reality environment. Together with the internet and other high-tech tools used for communicating, visualizing, and simulating, virtual reality delivers vital technical support for making constructivist type learning environments to supply learners with an authentic experience for learning (Bryant & Bates, 2015; Keengwe, Onchwari, & Agamba, 2014).

In the technology acceptance model, the users' behavioral intent to use a system represented an acceptance of the system (Wu & Chen, 2017). The use of the technology acceptance model and constructivist approach together could help developers build virtual reality environments capable of constructivist learning tactics to be used in educational and training applications. According to the Technology Acceptance Model,

acceptance of a system was signified by the intent to use the system, which was gauged by a user's attitude about utilizing a system and how useful it was perceived to be. The perceived ease of use and perceived usefulness dictated a user's attitude about using a system. Perceived usefulness is the degree to which a user believes that the use of an information technology system would enhance how him or her learns (Lai, 2017). Perceived ease of use is the measurement of a user's opinion about how easy it is to perform in a system. With TAM, a user's attitude influenced her or his behavior when utilizing an information technology system and would ultimately impact her or his performance (Lai, 2017). Virtual reality has been generally accepted by researchers as being beneficial for designing a substitute for the real world that could be used without losing contextual realness, since that contextual realness is an important component of TAM (Wu & Chen, 2017). Thus, whenever users interact with a virtual reality environment, they regard the environment as real when they actively participate in the learning (Muhanna, 2015). Still, developers should assess the actual user's intention and motivation for using a virtual reality environment prior to devoting time and energy to implementing the technology (Huang & Liaw, 2018). Designing virtual reality environments for certain educational reasons introduced a challenge because it involved having a broad understanding of virtual reality design, a familiarity with the topic at hand, and knowledge about related learning theories (Portman, Natapov, & Fisher-Gewirtzman, 2015). Considerable learning would not occur without users investing their time and energy. Some researchers asserted that good outcomes came when learning theories were integrated into a design (Qian & Clark, 2016).

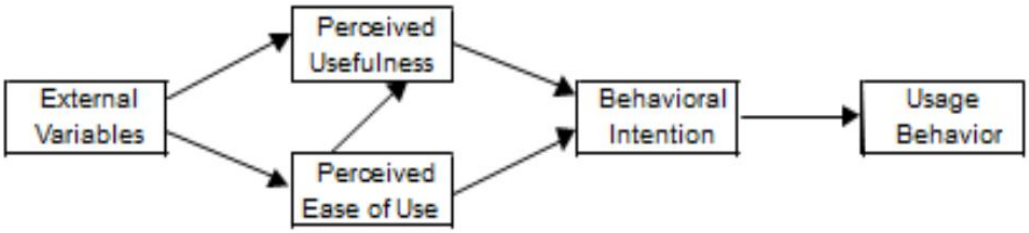

Figure *2.* Technology acceptance model. Reprinted from "The Literature Review of Technology Adoption Models and Theories for the Novelty Technology", by P. Lai, 2017, *Journal of Information Systems and Technology Management, 14*, p. 27. CC BY 4.0.

Flow theory. The flow theory was the basis for motivation in learning and games. Flow could be adapted in the game design in order to produce challenges that were in line with a user's skill level. This theory could be useful when designing virtual reality user interfaces for games (Shin, 2018). Some game developers ensured a user's skill level and the challenge level in the game were balanced to generate and sustain the flow. Yet, numerous educational games interfered with the flow by introducing some type of content assessment by using tests (Antonioli, Blake, & Sparks, 2014). Effective game developers used internal analysis to gather data on the users, adjusted challenges to keep the flow, and delivered feedback in a timely manner. Virtual reality games could use flow theory model to ensure learning through game play could continue smoothly while evaluations are done discreetly and so the flow is upheld (Antonioli, Blake, & Sparks, 2014).

When modern technologies are involved, the older models and theories like the ones discussed above have, as stated by Patel, Margolies, Covell, Lipscomb, and Dixon

(2018), fewer components than needed and lack the capacity to find and help with handling cutting-edge solutions. This could cause developers to identify the wrong tools and experiences for users.

Instructional design model. The instructional design model, as it pertained to the design of virtual reality-based environments, contributed in a major way to unleash huge possibilities for educational uses. Arghode, Brieger, and McLean (2017) shared that constructivism-based instructional design encouraged the construction of environments where users were actively building knowledge, instead of trying to reproduce what the developers interpreted the knowledge to be. The use of constructivism along with the instructional design model could give a developer another set of principles to help guide them when designing the virtual reality environment. The older principles of reliability, control, replicability, and communication recommended by the instructional designers differed a great deal when compared to the newer constructivist principles of user control, collaboration, reflexivity, and personal relevance (Bertrand, Guegan, Robieux, McCall, & Zenasni, 2018). The instructional design model would certainly support the constructivist theory by guiding the design of virtual reality environment user interfaces. As illustrated in Figure 3, the model contained three steps which included planning, design, and development.

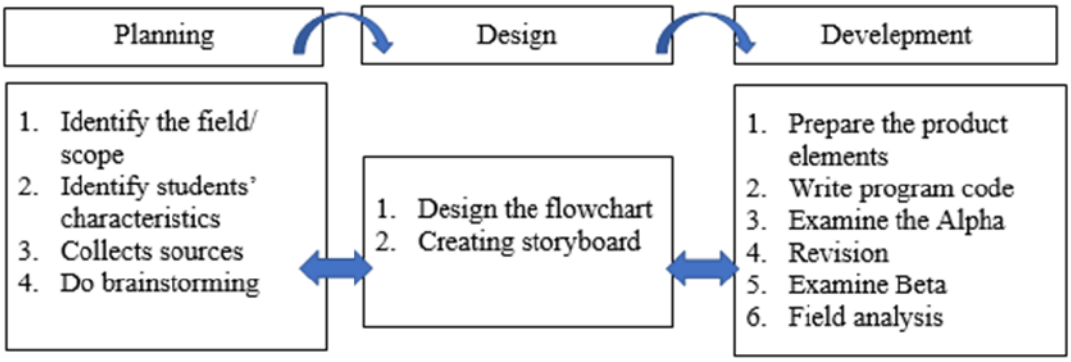

Figure *3*. Steps involved in instructional design model. Reprinted from "The Analysis of Students' Conceptual Understanding and Motivation in Guided Inquiry Science Learning Model Assisted by Android Virtual Laboratory", by A. Anam and W. Alimah, 2018, *Journal of Innovative Science Education, 7*, p. 409. CC BY 3.0.

The figure showed how the different steps were connected together. The planning step included an examination of the issue, need, goals, ideas for developing a product, and collecting resources. The design step involved the flowchart design and creation of the story board as well as the evaluation and review of the product. The development step involved preparing the different parts of the product, testing, revising the product if necessary, validating and evaluating the product. This instructional design model could be utilized along with the constructivist theory because it offered standards that could help a developer with designing and developing activities. This model also proposed approaches for exhibiting creativity and introducing design, development, and integration techniques for the different parts of virtual reality environment.

As found in the literature, the instructional design model also involved understanding and refining the instruction process. Instruction can be thought of as

deliberately combining the needed media, users, instructors, methods, information, and equipment in order to relay information and inform the learning (Moro, Štromberga, & Stirling, 2017; York & Ertmer, 2016). When an IT developer designs virtual reality environment user interfaces, their role is to learn a lot about the proposed outcomes, the virtual reality environment, the users, and then choose the instructional methods to help users reach the anticipated outcomes. Thus, instructional design stems from a sequence of instructional values or principles (Lee & Hannafin, 2016).

User Interface Design

Virtual reality environments are characterized by the interface, application, and dialog components which are encouraged by Seeheim's architecture for a user interface system (Guerrero, Ayala, Mateu, Casades, & Alamán, 2016). Based on the information discussed in the Gilbert et al. (2017) article, the application element was the virtual reality part which encompassed rules, features, and the knowledge that defined the application's logic. Nitti et al. (2016) stated that the interface element was part of the front-end that external objects and users utilized to share information and operate the system. According to (Roupé, Bosch-Sijtsema, & Johansson, 2014), an interface is made up of objects and data and that data represents user inputs received while the objects represent the entities within the interface whose identities and roles had been defined well. A dialog control allowed there to be communication amongst the interface and application. The details inside applications and the interface elements were clear to one another. This let developers and designers independently work on both parts.

Patel and Cassou (2015) stated that having an effective user interface design was very important whenever an application was being created to focus on learning. De Boer, Wesselink, and Vervoorn (2015) agreed that designers and developers were inclined to concentrate on the technology that was beneficial when designing two-dimensional user interfaces because they had insufficient knowledge about 3D systems which was necessary when creating a virtual reality environment that worked. If a virtual reality environment's interface is ambiguous, a user might either refrain from using the environment altogether or gain incorrect knowledge while using it. Górski et al. (2017) also mentioned that virtual reality environments and applications are not as effective if the user interface design does not promote a learning experience that is immersive. The design of the user interface is very important whenever a virtual reality environment is created, but there was little research available on the subject. Lorenz et al. cited that if a virtual reality environment's user interface was designed well, it could support and enhance the learning experience (2015). User interface design applies a constructivist and constructionist approach because the developers and users could construct an environment inside the virtual reality environment and the users could construct something that means a lot to them.

Within a learning environment, an interface has a special significance. Potkonjak et al. (2016) stated that when a user is engaged at the interface level in a virtual reality environment, the interface should respond just like in the real world. The primary concern for Cober et al. (2015) was how to create a simple and familiar interface for a multifaceted environment. The user interface in the virtual reality environment should be

a tool that offered an exchange between the computer and user. According to Martín-Gutiérrez et al. (2017), the focus should mostly be on the specifications of how users interacted using distinct commands. This method worked fine with graphical user interface and command language type interfaces. However, it was not enough to satisfy virtual reality interface requirements like object dynamism, implied interactions, and physical objects. Also, the communication between objects was not adequately addressed.

As cited by De Haan (2014), the command language grammar model was a user interface design developed by Moran that provided developers and designers with a prototype for describing and designing the interface. Kaklanis et al.'s article (2014) cited that this model split the user interface design into different levels, but there were limitations to how it was applied to virtual reality interfaces. Balatsoukas, Williams, Davies, Ainsworth, and Buchan (2015) explained that the object action interface model by Schneiderman was designed for GUI type interfaces and in order to satisfy the requirements for a graphical user interface type interfaces, that model placed emphasis on how important it was to visually represent the actions objects had. Hilfert and König (2016) also cited interactions handling objects directly. However, the object action interface model did not consider the characteristics of virtual reality interfaces that included implied style interactions, object dynamism, communication patterns between objects, and physical objects. According to Górski et al. (2017), another option for developers and designers was to utilize the object-oriented design methodology which was used for developing software. However, that methodology did not offer conceptual

guidance for handling explicit challenges with virtual reality interface design like the implied style interactions.

The lack of interface within a virtual reality environment may leave a user with no guidance on how to move within the virtual environment. Due to the absence of auditory and visual signs, users may be stuck in a virtual reality experience that turned out to be more puzzling than intuitive, resulting in them becoming frustrated and impatient. Even though the general idea of a virtual reality environment may be fascinating, executing the tasks could be misleading because simulating each action is difficult in a virtual environment. A virtual reality application may also become ineffective based on a totally different problem but might produce the same result in the end. Although the virtual reality environment may be equipped with a visually appealing interface, that does not share the purpose or functionality of the different environments. A user would once again be left to navigate through the virtual environment without visual and auditory direction which could lead to them wasting an excessive amount of their time performing different actions on the interface instead of in the environment. That is why it is important to create a virtual reality environment or application with an interface that is easy to understand and engages and prompts users while they are in the environment.

Exploring the unique mixtures of virtual reality environments and user interface designs in the literature was a challenge. The challenge was that there was a lack of research on the topic of strategies for virtual reality user interface design. Designing user interfaces is very important especially when trying to figure out an application’s usability as it could prevent a user from understanding the main goal. Furthermore, research

merging 2D user interface design with 3D environments is important when building an effective virtual reality environment. Physical actions that connected the interface and any material that corresponded should be considered when deciding on the intuitiveness and usability of the design.

Challenges for Virtual Reality Developers

As noted, the virtual reality industry is growing rapidly (Morrar & Arman, 2017). IT developers had been presented with the challenge of creating virtual reality user interfaces that appeal to, challenge, and keep users over a variety of virtual reality applications (Bastug, Bennis, Medard, & Debbah, 2017). Katz and Halpern (2015) stated that a successful virtual reality user interface would motivate users to explore the environment by presenting challenges that gave them delight when they succeeded in the virtual environment and accomplished meaningful tasks. According to Porter and Heppelmann (2015), a key objective for virtual reality environment developers was to create a user interface that attracted users and made the environment so interesting that the users believed that they were in the real world.

Adding objects without thinking about the forces that triggered the motion in virtual reality simulations could be a difficult task. Utilizing a desktop interface, a developer should choose the models that are manipulatable manually, the constraint type, and axes for movement. If a developer was not familiar with virtual reality design, they should seek help from someone who was experienced. As complex virtual reality environments were inclined to have more moving pieces, if kinematic constraints were included to an experience then it could have become very tedious.

Other challenges include hardware device selection, training, and user experience. Because the majority of virtual reality technology is still being researched, there are a limited number of companies utilizing the technology. Virtual reality hardware requires more attention. The basic structure of the hardware devices and knowing which practices lessen the delay between output and input devices must be understood so that users would be able to interact seamlessly with the environment and objects in virtual space. Training is required for the design of virtual reality environments. Muhanna (2015) and Serafin, Erkut, Kojs, Nilsson, and Nordahl (2016) stated that to ensure learnability and usability of a virtual reality environment user interface, training is required for the developer and users. Berg and Vance (2016) and Serafin, Erkut, Kojs, Nilsson, and Nordahl (2016) highlighted other challenges were those that users run into when learning how to move around in the virtual reality environments.

Future Directions

Many virtual reality applications have been created over the past decade. The trend for the future seems hopeful as it relates to how many virtual reality environments have been and would be developed. The interactions within a virtual reality environment is an important part to many virtual reality applications. The virtual reality technology was deliberately designed to imitate how individuals interpreted the real world. The virtual reality technology replaces information from reality with information within the virtual world. Computer processes imitated virtual worlds, images portrayed the simulation to the senses, and our minds combined the different parts to create the experience. When the design is good, a virtual reality experience may persuade users into

believing that they are physically positioned in the virtual reality environment. Creating a sense of presence put virtual reality in another category and forces older computing interfaces to another level. Although there was no requirement of having a sense of presence for virtual reality applications, sense of presence appears to be a main differentiator getting the attention of significant research.

As the software and hardware becomes more reliable, the operation of virtual reality applications is becoming easier. Yet, given the complex relationship between the technologies included, virtual reality is still not an end-to-end system that is immediately ready to use once implemented into business processes. One day, people may be as knowledgeable on virtual reality applications as they are the with desktop computers; but, in the current times that is not the case. A successful implementation of virtual reality system requires a collaboration of individuals with different abilities and skillsets. Virtual reality's value would be hard to realize if you have not experienced it personally. Virtual reality is not only hard to comprehend, but is also difficult to communicate. Unfortunately, since virtual reality is still an evolving technology, many companies hold their processes close in order to stay ahead of their competitors (Berg & Vance, 2016). More research needs to be conducted to understand the process of determining if a new technology is useful.

Constructionism and constructivism had come out in the past decade as the alternate theories for learning and were linked to the developments in educational technology. The interest in constructionism and constructivism had flourished because the theories were more open-ended, flexible, and adaptive. Therefore, constructionism

and constructivism were accepted by many IT professionals and that was echoed in the surplus of computer-based and multimedia software that originated from constructivist and constructionist methods. As a result, it turned into an idyllic foundation for creating a learning theory for open virtual reality environments.

Transition and Summary

Regardless of the involvement of IT software developers in the development of virtual reality environments, usability and ineffective environments remained a familiar theme within the industry. Diverse views about using virtual reality to improve cognition and learning had been seen in the past several years. The literature presented disagreeing opinions about the actual value that virtual reality interfaces brought. Virtual reality has quickly developed into a technology that could possibly match the transformation of the multimedia technologies. When viewing with a constructionist or constructivist perspective, both were theories focused on creating a variety of applications for understanding and learning. The literature review focused on the articles that discussed the aspects of quality that underlined the difference between virtual reality environments that users could navigate through and those users could not navigate through. From the articles reviewed on virtual reality published in the last five years, I only identified a few articles where researchers analyzed design strategies for virtual reality environments. The elements of quality that have been cited as they pertained to a virtual reality environment—immersive, intuitiveness, ease of use, usability, sense of being/belonging, and interactivity level—put emphasis on the differences. The literature also showed that the core issues related to virtual reality and learning had been the interest in the user

within the environment and not on environment's content. Virtual reality alone may not offer knowledge. There were concerns about the lack of tools to assess virtual environments in learning settings and the quality and reliability of the interpretation in the virtual environment.

The first section, Section 1, encompassed the problem statement, the purpose statement, and nature of study to support the use of an exploratory, multi case study design. In addition, Section 1 included: (i) the research and interview questions, (ii) the conceptual framework, (iii) the operational definitions, (iv) assumptions, limitations, and delimitations of the study, and (v) the significance of the study. Section 1 then concluded with the review of academic and professional literature. The literature review provided a complete overview of the works on the topic of the design strategies for virtual reality environments. The review of academic and professional literature included discussions on challenges with designing virtual reality environments and aspects of quality that could improve virtual reality environments in terms of usability, how immersive it was, interactivity level, and ease of use. The literature review also included a discussion of constructivism and constructionism as it related to learning and designing in virtual reality.

The second section, Section 2, consisted of: (i) a reiteration of the purpose of the study, (ii) the role of the researcher, (iii) the participants, (iv) the research method and research design, (v) the population and sampling, (vi) ethical research, (vii) data collection instruments and technique, data organization, and data analysis, and (viii) reliability and validity. The third section, Section 3, introduced the study's findings in

addition to a dialogue on the application to professional practice, the implication for social change, recommendations for action and further research, and a reflection of my experiences as it pertains to the research process. Also, in Section 3, I presented the results after completing the research and evaluating the data. I also drew conclusions and reported how it impacts society and the specific sample population.

Section 2: The Project

Purpose Statement

The purpose of this qualitative multiple-case study was to explore design strategies used by IT software developers to improve the quality of virtual reality environment user interfaces. The target population consisted of IT software developers in organizations around the San Antonio, Texas, area, who were selected because they had developed design strategies to improve the quality of virtual reality environment user interfaces. The impact that this study may have on social change includes increasing designers' and developer's understanding of ways to implement virtual reality user interfaces that are simpler and easier for the public to use.

Role of the Researcher

The researcher has an important role in qualitative studies because she or he serves as the key data collector (Berger, 2015). As the sole researcher in the study, I was the primary data collection instrument and was responsible for collecting, coding, and evaluating the interview data and company documents to reveal the patterns and concepts. I gathered data from each resource, analyzed the data collected, and then produced a report. In addition, I led all interviews, and I developed, designed, and implemented this study. It was my responsibility to elicit participants' views about their experiences with design strategies for virtual reality user interfaces. Onwuegbuzie and Byers (2014) agreed that the role of the researcher's is to elicit the participant's perspectives about a phenomenon. For this study, I created the interview questions, found potential organizations who had participants who met the criteria, organized and

facilitated the interviews, reviewed all data, and set up follow-up meetings to verify the accuracy of the transcribed data.

I did not have any prior experience with this subject matter, nor did I have any prior relationships with or connection to the participants. I had no hands-on experience in the virtual reality field, except when I participated as a player in PlayStation video games. I had entertained myself with virtual reality video games in the past and will keep on playing them. The lack of affiliation with the organizations and participants enabled me to conduct the interviews with more fairness. I have resided in the metropolitan San Antonio, Texas, area since 2015.

I collected the data from the selected participants once I received approval to begin research by Walden's University's Institutional Review Board (IRB), whose members evaluated my proposal to certify that it met the standards necessary for ethically protecting participants. Ethical research, as discussed in the *Belmont Report*, involves balancing goodness, respect, and justice for people in every study, which is partially attained by using informed consent (Grady, 2015; Metcalf & Crawford, 2016; Roberts, 2015). As the researcher, I made sure that every human participant was protected and treated ethically prior to, throughout, and after the study data were collected. I carried out research ethically when interacting with participants by showing them respect and taking precautions to ensure their protection by minimalizing harm to them. Conducting research in an ethical manner includes paying attention to the balance between benefit and risk, making sure that prospective participants are familiar with the risks and understand the benefit of study participation, and ensuring that prospective participants

control whether they participate or not (Grady, 2015; Metcalf & Crawford, 2016; Roberts, 2015). The balance was reached by ensuring that every participant was treated fairly, equally, and respectfully. I also completed the Collaborative Institutional Training Institute (CITI; 2018) online training program on the protection of human participants involved in research.

I also took steps to minimize the potential for researcher bias. Bias on my part could have influenced the results of the study and made it extremely difficult to be nonjudgmental and objective with my observations, thoughts, and actions. Conflicting goals that a researcher might have could present bias and impact the research (Roulston & Shelton, 2015). Roulston and Shelton (2015) explained that researcher bias is a prevalent problem within research. Personal beliefs and experiences that researchers might have related to a topic may influence a researcher's analysis and collection of data (Roulston & Shelton, 2015). Researchers should make every effort to remain transparent and be aware of their beliefs, feelings, and actions and how these might impact the results of the study (Probst, 2015). I understand that I may have introduced some bias into my study due to the experience I had with playing video games. To minimize the potential for bias, I designed the study to include open-ended questions, which helped in making sure that the responses from the participants were given without any influence from my own views. I also made sure that I took note of any bias that I had regarding the study subject matter before I collected the data, and I continued to be aware of the bias when I analyzed the data. This was why I used field notes to capture my personal feelings and

thoughts throughout the entire process. I used the notes to further recognize and bracket any of the thoughts I had when gathering and evaluating the data.

Other strategies for alleviating researcher bias are to use different types of data sources, perform interviews with multiple participants in a company, use an interview protocol, and perform member checking (De Massis & Kotlar, 2014; Hyett, Kenny, & Dickson-Swift, 2014; Yin, 1981). Adequate sources of data utilized to reduce bias include documentation, interviews, and observations (De Massis & Kotlar, 2014; Hyett, Kenny, & Dickson-Swift, 2014; Yin, 1981). My plan was to gather data from several sources, which would have included documents from the organizations such as procedure and policy guides, interview data, and observations. However, no documents were reviewed in this study because the three participating organizations did not provide approval for their internal documents to be used in this study. I did use member checking to help control researcher bias, and I made sure that my preconceived views, biases, and beliefs were put aside to preserve the integrity of data collected. To help avoid bias, researchers should welcome results from the data analysis even though they might be opposite to what they expected (Anney, 2014; Fusch & Ness, 2015).

I used an interview protocol to guide interviews and made sure there was consistency when I interacted with the participants. Interview protocols are generally used as a means of ensuring that there is consistency with structured research interviews (Levashina, Hartwell, Morgeson, & Campion, 2014). The interview protocol included the process to be used when facilitating the interviews as well as the interview questions. I used the interview protocol as a guide when facilitating the interviews. The interview

protocol helped me to remember to provide a short introduction about myself, which helped establish rapport, and to share important details concerning the study such as confidentiality, the study's purpose, and the informed consent document. When using an interview protocol, bias could be reduced or eliminated by making sure that every participant is asked the exact same questions in the same order. As Dikko stated (2016), interview protocols can help steer discussions with participants by making sure that the process of collecting data is consistent and has no unfavorable impact on the validity or reliability of the data from the interview. The interview protocol contains interview guidelines and a list of questions that will be asked in each interview (Castillo-Montoya, 2016). After each interview ended, I reviewed the interview protocol and make additional outreaches if feedback or clarification was needed, if I needed to ask follow-up questions, or if I needed to perform member checking. Using an interview protocol that has interview questions in it could also balance the power between the interviewee and participant by minimizing the potential for either the researcher or participant to dominate the interview as implied by Leins, Fisher, Pludwinski, Rivard, and Robertson (2014).

Participants

This research study included organizations that had successfully produced virtual reality environments. The participants were not work associates and represented IT software developers who were involved in the design of virtual reality environments within their organizations around the San Antonio, Texas area. With qualitative research, a researcher often searches for participants who are able to offer generous descriptions of an event or experience (Cheek, 2016). The participants selected should be able to offer

important information as it relates to the topic being studied (Sargeant, 2012). Recruiting participants is a significant part of research that involves humans (Collier, Moffatt, & Perry, 2015). They would be selected based whether they had experience with building virtual reality learning environments. I outlined these criteria to make the best use of the benefits of this research study all while lessening risk to the participants. Every participant served as a source of information and shared their perspectives based on their work as it pertained to building virtual reality learning environments for their organizations. Creating specific criteria for inclusion is particularly key in qualitative research since it assists with ensuring that the people who participate could offer information needed to address the research questions. To be specific, this study included participants who were IT software developers working in any of the following areas: corporate IT software developers; IT software developers who design virtual reality learning environments; or IT software developers who design virtual reality environments for video games.

In order to find organizations, I searched the internet for virtual reality design companies around the San Antonio, Texas area. I located numerous potential organizations around the San Antonio area and then found the contact information for the Chief Information Officer or equivalent. I reached out to the potential organizations via phone to explain the purpose of my study and then sought authorization to recruit their IT software developers to get involved in my research study. Once that had been accomplished, I requested a list of their employees that I could reach out to who fit my

criteria. The contact information needed included the employee's name, job title, email address, and telephone number.

I established a relationship with the participants in numerous ways. I explained the purpose of the interviews and encouraged each participant to share information from their experiences. I also explained the actions that were taken to ensure confidentiality, details about consent, and I explained the need for obtaining a written consent prior to the interviews being conducted. Creating a relationship with the participants is essential for having efficient and effective data collection grounded on the qualitative method (Yazan, 2015). Ensuring that participants know the researcher is part of their community creates a foundation for understanding with participants which is a way to establish rapport (Kornbluh, 2015). My intent was to learn about the organizations' culture and then adjust my behavior to reflect their standards. I worked with every participant when deciding on a location for the interviews to ensure that the meeting place was discreet and maintained their privacy. I made sure that the participants understood that the interview sessions were about their input and experiences and not my own. This might reinforce the participant-researcher relationship which could positively affect what participants are ready to share (Berger, 2015). I also created a relationship with participants by introducing myself and explaining the purpose of the study. After providing the purpose of the study, I got consent from every participant via email. The consent form pointed out the protections and rights afforded to them. I made sure that the consent form made participants aware that any data collected would be securely locked in an office drawer

and would be kept for a 5-year period and will then be destroyed after that time has passed.

Research Method and Design

Method

I used a qualitative methodology for this study. A key piece in the research process is selecting the proper research methodology and design that will allow the researcher to satisfy the study's purpose (Quick & Hall, 2015b). Using a qualitative study assisted me with exploring the design strategies for virtual reality user interfaces and let me develop the type of study that could aid future virtual reality environment developers with creating user interfaces. I considered qualitative, quantitative, and mixed methods for this study and had chosen to use the qualitative method. Qualitative research allows researchers to comprehend the perceptions or experiences and meaning participants share as it relates to certain topic (Gergen, Josselson, & Freeman, 2015). Conducting research using a qualitative methodology also helped me discover and gain an understanding into the participants' experiences and viewpoints as it pertained to design strategies for virtual reality user interfaces. Consistent with Gergen et al., Yazan (2015) suggested that qualitative methods are about fully comprehending a phenomenon by looking into how participants see or have experience it in their real-world setting. The objective of qualitative research is to understand what is being studied as seen through the eyes of participants (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). I got this information by conducting interviews. I asked the study participants to bring and share documents during their interview. I also attempted to obtain standard operating procedures and other

organizational documents that expanded on the guidelines for quality. This was requested from each organizations' leadership at the beginning of our communication. I had chosen to use open-ended questions during my interviews because they helped me to explore the research question in more detail. The researcher must discover how participants make decisions related to the topic and this should be the purpose for the research (Barnham, 2015). Participants' insights in conjunction with their experiences create the basis to research the event being studied in qualitative design (Fusch & Ness, 2015). Since I tried to learn more about the design strategies software developers used to improve the quality of a virtual reality environment user interface, the qualitative method was more appropriate.

Before making the decision to use the qualitative methodology, I contemplated using the quantitative methodology. Researchers use a quantitative methodology to measure, identify, and explain the relationships between facets of an issue defined with variables (Steele & Rawls, 2015). This type of research studies relationships among variables by measuring their values (Quick & Hall, 2015a). The researcher then examines the numbers from the data to test and validate the relationships (Landrum & Garza, 2015). The purpose of my study was to research strategies IT software developers use to improve virtual reality user interfaces as opposed to testing a hypothesis or idea. I decided that the quantitative methodology was not suitable for this study since I was not going to explore differences and relationships between variables or test a hypothesis.

I also thought about using the mixed methods methodology because it used both the qualitative and quantitative methods together. The mixed methodology encompasses

a blend of quantitative and qualitative methodologies into one study (Yazan, 2015). With mixed methods, researchers use the quantitative research for measuring the event or experience and use qualitative research to examine perceptions and experiences of participants regarding a particular event (Kaur, 2016). This method involved extensive analysis and data collection, a level of expertise in both qualitative and quantitative methods, and ample amount of time to carry out both studies. The mixed methods approach blends the strong points from both quantitative and qualitative research methods to improve the accurateness of the findings gained through the research (Imran & Yusoff, 2015). The use of the mixed methodology could offer extensive awareness of an event or experience; yet, blending quantitative and qualitative methodologies into a single study could be time-consuming and too complex for a researcher (McCusker & Gunaydin, 2015). Even though there were various advantages to utilizing mixed method, this was not a suitable method for my study because I was not determining quantitative differences or relationships.

Research Design

Out of the widely used qualitative designs, I determined that using the case study design for my study was the best decision. Case studies revolve around describing the intricacy of the event or phenomenon being studied (Houghton et al., 2015). The phenomenon or event being studied is an actual case that researchers can study while in its normal setting (Gergen et al., 2015). The phenomenon in this study was the development of quality virtual reality environment user interfaces by the software developers. I selected this design for my study because I was focusing on a precise case

of virtual reality user interface design and the development processes associated with it. I collected data through methods that consisted of interviews in order to find themes within the results. A more thorough description of the phenomenon could be achieved by using several sites which is identified as a multiple-case study because numerous data sources are being analyzed (Kim, Sefcik, & Bradway, 2016). The main difference with case studies versus other research types is that the case turns into the central point for the research as opposed to the participants (Yazan, 2015). I used a multiple case study as opposed to a single case study. A multiple case study allowed me to examine different design strategies for effective virtual reality user interfaces and offer more validity than the single case study. My goal was to compare numerous design techniques to creating quality virtual reality user interfaces.

Ethnography, phenomenology, and case study are the more frequently used designs in qualitative research. Ethnography is fixated on understanding beliefs, languages, and behaviors of individuals within a social group (Vom Lehn & Hitzler, 2015). With an anthropology background, ethnography involves the researcher dedicating a substantial amount of time engrossed in the day-to-day activities of the individuals being studied (Draper, 2015). This direct exposure is key for the extensive descriptions necessary in qualitative studies (Nassaji, 2015). My study did not need comprehensive knowledge about the culture of IT software developers, nor did it need comprehensive knowledge on how virtual reality user interface design decisions personally impact the developers. My study explored design strategies used by IT software developers for improving the quality of the virtual reality environment's user interface. The focus was

not on the IT software developers themselves or their behaviors, so ethnography was not a good fit.

Comprehending the main idea could be accomplished by examining the experiences of people who have actual experience with that event or phenomenon (Yazan, 2015). Phenomenology is important because a researcher will outline what the phenomenon or event is being studied and how people experience it (McCusker & Gunaydin, 2015). I did not select the phenomenology design because it was not my goal to understand how the shared experiences between software developers were influenced by virtual reality user interface design or how the software developers were impacted by a process themselves. Phenomenology has a background in philosophy and psychology and a purpose of comprehending the main idea behind an event or phenomenon (Houghton, Murphy, Shaw, & Casey, 2015).

Data Saturation

Data saturation is an important part of case study research. In order to make sure there was data saturation, I continued collecting data with the participants and used open-ended questions that resulted in rich, thick data until the responses did not produce new information. Data saturation is an important element when using qualitative case studies (Roy, Goldberg, Sharp, & Larossa, 2015). Data saturation is attained when no more new data is identified or redundant data continues to surface (Collier et al., 2015). Using effective sampling techniques can lead to data saturation (Fusch & Ness, 2015). A study's sample size would be considered suitable if there are enough individuals

participating to achieve data saturation (Roy et al., 2015). If data saturation is not achieved, the study's quality will be affected (Fusch & Ness, 2015).

I achieved data saturation in this study in a number of ways. First, I collected data from the semi structured interviews that focused on strategies used to improve the quality of virtual reality environment user interfaces. There were an adequate number of interview questions asked to reach data saturation, and I made this happen by presenting the participants with penetrating questions throughout the interviews. When attempting to achieve data saturation, enough information should be obtained that will allow the study to be replicated (Fusch, & Ness, 2015). By interviewing all software developers, I was able to achieve data saturation by obtaining all necessary information from every participant based on the question used in the interview. Use of the census sampling technique will allowed me to examine the views from each software developer regarding the design strategies used to improve the quality of virtual reality environment user interfaces. Data saturation was achieved when the participants had no new data to provide. Also, I used member checking to make sure I had a complete and accurate understanding of the interview data. I met with every participant after the initial interview to ensure I interpreted the interview data correctly and summarized their viewpoints accurately. The participants had the opportunity to review and confirm if my understandings and synthesis of the interview data were accurate. If my interpretation of the data was incorrect, then corrections were made, and I reevaluated the new data and followed up again as needed until no further corrections were needed. The follow up member checking meetings were conducted in person, via email, or via the telephone,

whichever was more convenient for the participant. Then, I used the census sampling technique with my population in order to inform the research. I also used methodological triangulation by utilizing transcription software to transcribe audio files into text files and thematic analysis for data coding. Methodological triangulation is when several data sources are used that relate to a particular phenomenon or case, in a case studies, to obtain various views, increase data validation and reliability, and to build clear explanation of the interpreted data (Durif-Bruckert et al., 2014).

Population and Sampling

The population for my research was IT software developers in organizations located around the San Antonio, Texas, area in the United States, who had experience with building virtual reality environments, and who were not my work associates. These criteria were applied because they could yield detailed information on the research topic. This was consistent with the eligibility conditions established for choosing participants from the organizations. As said by Hanson et al. (2016), the thing that is needed for choosing participants for qualitative case studies is the eligibility criteria because it helps with defining the needed population or participants. The potential organizations that I used had an estimated ten to twelve IT software developers between them that met the criteria for my study. Since the total number of IT software developers in the potential organizations was so small, I used the entire population in this study.

Purposeful sampling is considered as an accurate approach to use when selecting cases for qualitative studies (Patton, 2015). Purposeful sampling strategy involves choosing sources that offer in-depth information about the issue being studied (Gentles,

Charles, Ploeg, & McKibbon, 2015; Salvador, Goodkind, & Ewing, 2016). Furthermore, purposeful sampling is mostly utilized by researchers conducting qualitative case studies (Gentles, Charles, Ploeg, & McKibbon, 2015; Pacho, 2015), particularly where it is hard to choose samples randomly to signify the tools for measuring in case studies (Palinkas, et al., 2015), and where the objective is sampling comprehensive or information-rich cases (Yazan, 2015).

I used the census sampling technique because it was a better fit for this case study design. Studying everyone within the target population is considered census sampling (Fusch, Fusch, & Ness, 2017). A census sampling technique was used to choose all 6 software developer participants from multiple organizations that qualified utilizing the eligibility criteria. The eligibility criteria consisted of software developers from multiple organizations who had experience with designing strategies for virtual reality user interfaces around the San Antonio, Texas, area. Generally, census sampling is suitable for use in studies where participants are knowledgeable about the issue being investigated (Pogrund, Darst, & Munro, 2015). By using the census sampling technique, I was able to examine all views from the entire population of 6 software developers as it pertained to design strategies used to improve the quality of virtual reality environment user interfaces. There was an adequate number of interview questions to help me reach data saturation and this was possible because I asked each participant open-ended and penetrating questions throughout the interviews in order to obtain rich, detailed information. I reached data saturation when the participants had no new information to provide. Random sampling was not used to choose the participants since it was not

suitable for my qualitative case study. According to Ingham-Broomfield (2014), random sampling is used frequently in quantitative studies. I examined the whole population of 6 software developers for this study as opposed to sampling a small subgroup of participants like was involved in random sampling. I then requested a participant list from the organizations. Deciding on an acceptable number of participants is important in the data collection process (Malterud, Siersma, & Guassora, 2016). If a small-sized group is used, it would not deliver as much information-rich data as compared to a bigger group (Roy et al., 2015). Yet, having a large number of participants is challenging for researchers to manage (Roy et al., 2015). The sample size will be considered suitable if the number of participants is enough to have data saturation (Palinkas et al., 2015). Since I was using a census sampling technique in my study that allowed me to include the entire population of participants that met the criteria for eligibility, sample size was not an issue. When participants were selected for my study, they had experience with design strategies for virtual reality user interfaces and were also a software developer located around my local area.

When it comes to reaching data saturation in qualitative case studies, different researchers agree that it is reached by continuously collecting sufficient data so that more input from additional data sources does not produce new information (Fusch & Ness, 2015; Veletsianos & Shepherdson, 2016), keeps on impacting research questions (Suárez-Guerrero, Lloret-Catalá, & Mengual-Andrés, 2016), or produce additional themes (Coorey et al., 2017). To ensure data saturation, I wanted to collect data from different sources including organizational documentation and participant interviews. None of the

organizations approved release of their internal documents for this study. The organizational documentation would have focused on strategies used to design virtual reality user interfaces. Analyzing documents would have been used with other methods as a way to exhibit triangulation. I wanted to use organizational documents to supplement the interview data. I also wanted to review the organizational documents and synthesize them to make sense of the data. I did categorize the interview data and found the main themes. Examining information collected through different methods would have helped me corroborate the data in the study in order to reduce biases that may exist. Owen (2014) stated that document analysis could provide information on the background of a topic before the researcher conducts the interviews. Document analysis could also corroborate or refute the interview data. For me, the goal was to create credibility with the study (Owen, 2014). If I found that the information from the different documents reviewed shared a common theme, then the individuals reading my study may have more confidence in the findings. Unfortunately, the organizations were not in a position to share their internal documentation during the time of the research. I did interview every participant and asked open-ended questions that would produce rich and thick data resulting in no more information needed. A number of authors approved the idea that researchers have a better chance of reaching data saturation when there is rich and thick data as opposed to basing it off of sample size alone (Azmat & Rentschler, 2015; Morse, Lowery, & Steury, 2014). My interviews were made up of open-ended questions and I insisted that all participants share the experiences they had with developing virtual reality user interfaces. I engaged in methodological triangulation through the use of a research

database, transcript service to transfer the audio data into a text form, and I performed an analysis to record patterns and themes within the data. I implemented member checking by scheduling follow-up meetings with participants to review transcriptions to ensure there was saturation. Member checking is another way to achieve saturation because it enhances the reliability of the analyzed data and how the participant are involved (Varpio, Ajjawi, Monrouxe, O'Brien, & Rees, 2016). Member checking gives participants the chance to review how the researcher interpreted their data (Thomas, 2016) and allows them to provide additional information or corrections (Morse, 2015a).

I worked with the participants to find acceptable meeting settings that met the criteria for being comfortable, convenient, and private. When carrying out in-person interviews, the setting for an interview could have a huge impact on the actual interview (Dempsey, Dowling, Larkin, & Murphy, 2016) because it is an important part in an interview process. (Gagnon, Jacob, & McCabe, 2015). It is recommended that the location of the interview be comfortable, convenient, and make the participant feel safe when they are engaging in open conversations (Rimando et al., 2015). This lets participants freely share their perspectives in an environment that is comfortable, convenient, and private to them. The setting that was approved had the least amount of disruption. I also took notes and recorded the interviews. Using audio recordings with interviews can help researchers sort items to find themes related to the study (Grossoehme, 2014). I obtained permission from the participant prior to recording so that I could get an accurate interpretation of the interview which could be played back for

analysis. Participant identity remained confidential throughout the recording. The recordings were transcribed and used later in the study.

Ethical Research

Before communicating with prospective study participants, I had to obtain approval from Walden University's IRB. The Walden University IRB assessed my proposal to make sure it met the university's standards for ethically protecting participants. Once they assessed the proposal, they provided their approval and issued an approval certificate. I abided by the legal and ethical requirements set forth by Walden University's IRB (Walden University, 2016). The IRB verifies that research exceeds or meets ethical standards prior to a study being completed. (Nebeker et al., 2016). The IRB protects participants from any harm that comes as a result of the research (Winkler, Witte, & Bierer, 2015). IRB guiding principles require that every participant give consent to participate in a study (Emanuel, 2015). After receiving approval from the IRB, I e-mailed a consent form to the prospective participants. Every participant had a chance to look over the consent form, provide their consent, and ask questions prior to the data collection process began. The informed consent contained details about the consent, participant selection criteria, withdrawal option, participation incentives, identity protection, and data retention policies. Participation in the research study is voluntary and participants should be informed of the guidelines for withdrawing (Melham et al., 2014). I upheld high ethical standards during all the phases of my interviews. I made sure that the main ethical principles of beneficence, respect for person, and justice were adopted entirely as recognized in the *Belmont Report* (National Commission for the Protection of

Human Subjects of Biomedical and Behavioral Research, 1979) since they signified the major ethical concerns for protecting human participants in research. The *Belmont Report* is considered to be the ethical guide for protecting human participants in research (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). I also completed the Collaborative Institutional Training Institute (CITI) online training program on the protection of human participants involved in research.

I created a cooperation letter (see Appendix A) and participation invitation letter (see Appendix B) to request permission from organizations and individual participants, respectively. When seeking approval from a research ethics committee, researchers should address important aspects such as confidentiality, data protection, informed consent, data storage, anonymity, and the safety of participants (Liaw & Tam, 2015). Permission must be given prior to the interviews with participants. The first step was to request permission from the decision maker of the organization to sign the cooperation letter. The next step was to request that every participant read and sign the informed consent form prior to participating in the study. There were emailed copies of the informed consent document for each participant to sign and this was so that they could keep a copy for themselves. The informed consent provides every participant the option to participate voluntarily in this research study and withdraw any time (Killawi et al., 2014; Wong & Hui, 2015). The consent form contained information that the participant would need to understand why they were chosen for this study, the researcher's identity, a description of the purpose of the research and information on participants getting

compensated for their participation in the study. As an essential condition for the ethical treatment of human subjects' in research, the participants were made aware, by way of the informed consent form, that they had the right to refuse to participate in this study prior to, during, or once the data was collected. If a participant decided to withdraw during or after the data collection process, any data that had already been collected from them would be deleted and the participant notified. I provided participants with enough information so that they could make the best decision as it pertained to participating. Part of the process of getting informed consent was communicating the purpose of the study to every participant prior to beginning the interview. Per the *Belmont Report*, when it comes to comprehending research study information and volunteering to participate, participants have the right to participate in a study if they choose and withdraw at any time (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research,1979; see also Miracle, 2016; Morello-Frosch, Varshavsky, Liboiron, Brown, & Brody, 2015; Wong & Hui, 2015). Every participant was reminded about confidentiality, the purpose of the study, that they were voluntarily participating, that they had the right to skip any question(s) that they did not wish to answer, and that they could decline to participate in the study at any time and withdraw the information already provided without penalty even after the data collection process was completed. The informed consent form also indicated that there was no incentive or payment available for being involved in the study. When enlisting participants for the interview, deciding whether or not give incentives is an important decision that researchers have to make. The advantage of offering incentives to participants are that they improve the

probability of participation because it would be considered a form of motivation (Robinson, 2014). The drawback is that it could encourage participants to fabricate information during the interview just so they can get the incentives (Robinson, 2014). However, in this study no incentives were given to participants.

I will keep and protect every electronic and hard copy of the data I collected for a period of five years. The electronic data is stored on an external hard drive. The external hard drive and any hard copies of the data are stored in a locked safe inside my office desk and only I have access to it. After the five-year period, I will place the hard copy papers in a document shredder and will delete all of the electronic documents off of the external hard drive. The IRB rules also call for researchers to assurance the confidentiality and privacy of all participants (Hébert et al., 2015). I used ID codes to protect the participants' identities (Ranney et al., 2015) in order to protect their confidentiality. I referenced the participants and organizations in this study with codes names and I was the only one who knew the identity of the participants. The identity of the organizations and participants remained confidential. Aliases or codes have been used in many cases to conceal identities (Owen, 2014; Petrova, Dewing, & Camilleri, 2014; Ranney et al., 2015). I maintained anonymousness by utilizing codes like 'org1' to represent organization names and 'part1', 'part2', ...'partn' to represent participant names. This helped make sure that all data, audio files, and interview transcriptions contained codes instead of actual organization and participant names.

Data Collection

Instruments

In my qualitative case study, I served as the main data collection instrument and remained in close communication with all participants. Researchers in qualitative studies are the main data collection instruments (Fusch & Ness, 2015; Vohra, 2014). The researcher's skills, sensitivity, and knowledge are vital to the knowledge generated when a researcher is the main research instrument (Hermanowicz, 2013). The data collection for this study was made up of interviews. Data collection can generate a substantial amount of data from numerous resources (Palinkas et al., 2015). The resources could include semi structured interviews, company documents, researcher observations, and other publicly issued documents related to the research topic (Vohra, 2014).

The beginning phase in my data collection process consisted of a review of the organization's documents where I was the main data collection instrument for this case study. I asked the study participants to bring and share documents during their interview that supported the idea of improving quality. I also attempted to obtain policy and standard operating procedures and other organizational documents that expanded on quality guidelines. This was requested from each organizations' leadership at the beginning of our communication. My goal was to obtain and evaluate relevant organizational documents such as training and design documents which would help increase the reliability of the data. Analyzing company documents is a way to review or evaluate information in order to gain meaning, a better understanding, and more knowledge about the topic (Wieland et al., 2014). Reviewing pertinent organizational

documents can increase rigor and data reliability (Baškarada, 2014; Cronin, 2014). The plan was that after I got and examined documents, I would have identified the main virtual reality design strategies and practices and themes that emerged for best practices. Furthermore, reviewing the documents would have provided more understanding about IT software developers' effective design strategies for improving virtual reality user interfaces. The next phase included conducting and recording semi structured interviews with the participants. Fusch and Ness (2015) stated that using interviews as a data collection tool could help ensure a researcher has data saturation. The semi structured interview has an important role in data collection because it involves extracting information using steered conversations with participants (Dikko, 2016). Personal interviews are an effective type of qualitative data collection (Morse & McEvoy, 2014). They are effective because emotions and human interactions are involved (Pacho, 2015). The favorable way to conduct in-person semi structured interviews is in a setting that will encourage descriptive experiences allowing responses from participants (Khan, 2014b). Email and telephone interviewing techniques are valid too; yet, they do not allow the researcher to observe participant interactions (Khan, 2014c). Throughout the interviews, follow-up questions were asked so participants could explain ideas, or I could obtain more information. I made participants aware beforehand so they could opt-out of the interview process at any time without penalties since participation was totally voluntary. I conducted interviews with the participants until the entire population of 6 participants were complete and they provide no new information.

I used an interview protocol and open-ended interview questions (Appendix C) to gather data on participants' experiences as they related to design strategies for virtual reality user interfaces. Before the interview began, the participant had the chance to acknowledge and agree that the interview could be recorded. After every interview, participants were able to ask their questions and provide other data. Appendix B includes the letter that was used for recruiting participants. Appendix C contains the questions that were used for the interview and a summary of the interview process that was used to gather the information from each participant. Review of the organizational documentation could have assisted me with gathering information on the virtual reality user interface development process as it pertained to my research question and also any information that supported the topic outlined by my interview questions. The information that would have been included in the organizational documentation that needed to be reviewed would have been assumed to be true and complete.

I utilized member checking to improve the validity and reliability of the instrument used for collecting data. I facilitated the interviews and conducted follow-up meetings with every participant until the responses resulted in no new information being found. Member checking is key validation component in qualitative research and helps confirm if a researcher correctly reports the participant's account of their experiences (Harvey, 2015; Madill & Sullivan, 2017; Palinkas et al., 2015). Also, member checking verifies how interviews are interpreted and improves the reliability of data (Cleary et al., 2014; Fusch & Ness, 2015). Additionally, using member checking will ensure the correct meaning is captured along with the choice of words (Elo et al., 2014; Pacho, 2015). Elo et

al. (2014) expressed that technical advancements in automated approaches afford researchers quicker and more precise ways to interpret, code, and evaluate the data collected. Member checking helps with trustworthiness and reliability in qualitative research (Madill & Sullivan, 2017; Nottingham & Henning, 2014; Palinkas et al., 2015).

To maximize data validity and reliability, I transcribed and interpreted every interview, presented participants with a summary of how I interpreted their interview transcription files to be member checked, and requested feedback on how accurate the data was. Member checking can be done during the data collection process to check the data between each participant (Morse, 2015a). If participants were unavailable for a follow-up meeting, they received an e-mailed copy of the interpreted interview data for member checking and a request to return feedback within a couple of days. Providing a summary of the interpreted data to participants to verify if the data, descriptions, or interpretations are accurate is part of the process (Harvey, 2015). I ensured that participants understood that if they did not respond in the stated period of time, they would be confirming that the data interpretation was accurate. No feedback from participants will be interpreted as validation that the data is correct (Simpson & Quigley, 2016). If a participant provided feedback, then I synthesized the information again and setup another follow-up meeting for feedback. If the participant was unavailable for a follow-up meeting, I sent out an updated summary via email within two days for more feedback. If within two days the participant provided no additional feedback, that would mean they were agreeing that the data was accurate. After member checking was

complete, the data interpretation files were put in a database so the data collected could be categorized, coded, and grouped by themes for further analysis.

Data Collection Technique

Researchers can choose from several different techniques for collecting qualitative data. Some of these techniques include reviewing archived records, reviewing organizational documents, conducting interviews, making observations, and even reviewing reflective journals (Onwuegbuzie & Byers, 2014; Pacho, 2015). In addition, research professionals mentioned that the use of several data sources increases the reliability and validation of data (Morse & McEvoy, 2014; Pacho, 2015). I wanted to review the organization's documents that were relevant to my research but was not provided any. I did, however, conduct interviews with participants. As expressed by Baškarada (2014) and Kalu (2017) evaluating organizational documents and resources will provide an extra data collection technique to get qualitative research. It was suggested that in order to get the most out of interviews, several sources of evidence could be used which consist of interviews and a review of documents (Morse & McEvoy, 2014; Pacho, 2015). Furthermore, Gentles et al. (2015) suggested that researchers could review relevant organizational documents like company policies, magazines, sustainability reports, or procedures prior to doing the interviews. When researchers utilize a constant data protocol, it improves cross-case evaluation in qualitative research (Baškarada, 2014; Elo et al., 2014). Using thick descriptions for case study research involves gathering rich specifics about the particular case and determining the intricate levels of understanding the experiences of participants (Baškarada, 2014; Elo et al., 2014;

Pacho, 2015). Acceptable full descriptions as they relate to the issue being studied is necessary in order to understand the background of the case (Hyett, Kenny, & Dickson-Swift, 2014). I described the background utilizing rich, full descriptions.

Once I received IRB approval and had authorization from the potential organizations, I contacted the prospective participants utilizing the contact information supplied to me by the organization. Upon request, I sent every participant a copy of the cooperation letter from their organization (Appendix A). I also sent participants the consent form once they expressed interest in getting involved. Once the consent forms were returned, I scheduled the interviews and selected a time and place that was convenient for the participant. I used the interview protocol (see Appendix C) to make sure that every participant was asked the same interview questions in the same way to decrease or remove bias or discrepancies that could unfavorably affect the validity or reliability of the data from the interview. I recorded the interviews and then transcribed and examined the data. I also worked in partnership with the authorizing representative from the organization when requesting access to the organizational documents.

Semi structured interviews that consist of open-ended questions offer the interviewee and interviewer the chance to expand on the topic being studied (Jamshed, 2014; Morse & McEvoy, 2014). The next portion of the data collection process for this multiple case study consisted of multiple interview meetings that used a uniform set of seven to ten questions to examine and study IT software developers' experiences as they related to design strategies for virtual reality environment user interfaces. Interview procedures should include the research questions and should guide researchers through

the whole interview process (Castillo-Montoya, 2016; Pacho, 2015). Appendix C displays the interview protocol which was used to make sure the interviewer asked every participant the exact same question in the exact same order throughout the interview. I conducted telephone and Skype semi structured interviews at a specified location by utilizing the interview questions from Appendix C to evaluate the participants' experiences as they relate to virtual reality design strategies. At the end of every interview, I gave participants a chance to ask questions and/or offer other information.

One advantage of conducting interviews is that research has the chance to assess the participants' actions and gestures. Interviewing could help make sure there is a common understanding amongst the participants and researcher, thus providing suitable answers and more precise data. Interviews typically give researchers a higher response rate and the chances of receiving incomplete answers is low. Another advantage to using interviews with a case study is having the ability to contact several participants in a single location setting. Interviews offer the benefit of establishing a relationship and creating a connection with participants (Mealer & Jones, 2014; Wolgemuth et al., 2015). A disadvantage is making it tough for participants when they are required to travel to the predetermined interview site. If interviews are filled with researcher bias and participants feel that the interviews are somewhat intrusive, it could serve as a disadvantage to researchers (Haahr et al., 2014; Morse, 2015b). I lessened researcher bias by putting aside my personal judgements and views. Utilizing organizational documents would have been advantageous because they could enhance the research data in the qualitative study.

However, the disadvantage to using this type of information is that it might be inaccurate, misleading, or obsolete (Latunde, 2017; Lewis, 2015; Yin, 2014).

The concept being measured by the data collection instrument was to understand design strategies for developing user interfaces in virtual reality environments. The collection of the participant data was through telephone and Skype semi structured interviews. The interview method was a joint partnership between the participants and interviewer. The interviewer guided the dialog with participants and then encouraged them to elaborate on their responses in order to document the rich descriptions. Providing participants with a cue might result in the interviewer receiving a more detailed description of participant experiences which in turn would yield a richer analysis report (Baškarada, 2014; Elo et al., 2014). Throughout the semi structured interviews, my hope was that the participants would discuss what design strategies were used when developing user interfaces in virtual reality environments. I interpreted every recorded file and transcribed it into a text format in order to validate the data. Transcribing is a difficult process that should be completed in order to translate the verbal words to a written form to make analysis easier (Sutton & Austin, 2015). Transcripts should be formatted to make coding easier and to match the standards of the software the researcher will use when doing the data analysis (Ranney et al., 2015). Researchers have also expressed how important it is to keep the field notes taken during interviews after every interview (Cronin, 2014; Pacho, 2015). A reason to take notes during data collection is that it could serve as a preliminary approach for analysis (Ranney et al., 2015). Furthermore, taking field notes right after every interview would provide the researcher

an opportunity to document the participants' actions and feedback as it relates to the results and interview (Kornbluh, 2015). When analyzing the data, the process consisted of reading the transcribed data two times to confirm the accurateness of the interpreted recording against the actual voice recording. Member checking is a key element of reliability and assists with interpreting data and validation (Harvey, 2015; Madill & Sullivan, 2017; Nottingham & Henning, 2014). To make best use of data validity and reliability, I provided every participant with a copy of the transcribed data interpretation file for member checking. I also requested feedback on the accuracy of the data. After all of the interviews were completed, I categorized, coded, and grouped the collected data into themes based on an evaluation of participant interviews for more analysis.

There are benefits and drawbacks to every data collection technique. The use of document reviews is beneficial because they are low-cost, offer background information, and might highlight the issues not exposed by other data collection techniques (Kutsyuruba, Godden, & Tregunna, 2014). The main drawback to using document reviews is how long it takes to gather, review, and evaluate the large amounts of data which might not be complete or might not be available inside the research study period (Owen, 2014; Pacho, 2015). Interviews deliver benefits by encouraging participants to go into details and describe what they consider to be the most important aspects as it pertains to the topic of study (Pacho, 2015; Robinson, 2014). A major drawback to utilizing interviews is bias (Elo et al., 2014; Pacho, 2015; Robinson, 2014.

Data Organization Techniques

I wanted to first review any documents provided by the organization that were relevant to my research. However, no documents were provided by the organizations. Research professionals mentioned that the use of several data sources increases the reliability and validation of data (Morse & McEvoy, 2014; Pacho, 2015). As expressed by Baškarada (2014) and Kalu (2017) evaluating organizational documents and resources will provide an extra data collection technique to get qualitative research. It was suggested that in order to get the most out of interviews, several sources of evidence could be used which consist of interviews and a review of documents (Morse & McEvoy, 2014; Pacho, 2015). Furthermore, Gentles et al. (2015) suggested that researchers can review relevant organizational documents like company policies, magazines, sustainability reports, or procedures prior to doing the interviews.

My interview sessions were semi structured so that I could explore and get additional information from participants. Researchers can choose from several different techniques for collecting qualitative data. Some of these techniques include reviewing archived records, reviewing organizational documents, conducting interviews, making observations, and even reviewing reflective journals (Onwuegbuzie & Byers, 2014; Pacho, 2015). My plan was to use methodological triangulation to help me get a greater understanding of the virtual reality design strategies used by software developers. Using triangulation would offer an in-depth understanding for collecting different perspectives that are related to the research study issue from every aspect as explained by Carter, Bryant-Lukosius, DiCenso, Blythe, and Neville (2014). Semi structured interviews that

consist of open-ended questions offer the interviewee and interviewer the chance to expand on the topic being studied (Jamshed, 2014; Morse & McEvoy, 2014). During the data collection process for this case study, interview meetings were setup to use a uniform set of seven to ten questions to examine and study software developers' experiences as they related to design strategies for virtual reality environment user interfaces. I asked the participants non-leading questions to solicit a response with thick, rich descriptions of the experience they had with virtual reality user design strategies from a participant's viewpoint. Using thick descriptions for case study research involves gathering rich specifics about the particular case and determining the intricate levels of understanding the experiences of participants (Baškarada, 2014; Elo et al., 2014; Pacho, 2015). Acceptable full descriptions as they relate to the issue being studied is necessary in order to understand the background of the case (Hyett, Kenny, & Dickson-Swift, 2014). Appendix C displays the interview protocol which was used to make sure the I asked every participant the exact same question in the exact same order throughout the interview. I conducted telephone and Skype semi structured interviews at a specified location by using the interview questions that are also in Appendix C to evaluate the participants' experiences as they related to virtual reality design strategies. Interview procedures should include the research questions and should guide researchers through the whole interview process (Castillo-Montoya, 2016; Pacho, 2015). At the end of every interview, I gave participants a chance to ask questions and/or offer other information.

I maintained a record for developing understandings during the research process by using a journal. The journal can enable researchers to log experiences in an organized

manner and could also offer a means of escape for thoughts not recorded elsewhere within the results (Herrington, Parker, & Boase-Jelinek, 2014). Use of this type of journal represents how professionals and researchers comprehend things (Dyment & O'Connell, 2014; Ibrahim & Edgley, 2015). As stated by Rahgozaran and Gholami (2014), reflective journals reach past a limited focus because it supports researchers so they can take a complete assessment of their experiences. Reflective journals offer researchers a way to encourage thinking critically (Starr-Glass, 2014), help them know their process during research (Orange, 2016), think about their research with regard to the content of the study (Mayes, Dollarhide, Marshall, & Rae, 2016), and to notice qualities within themselves that they were oblivious of before (Vandermause, Barbosa-Leiker, & Fritz, 2014). I recorded what I was thinking as I journeyed through the research process in several phases which include formulating the prospectus, putting the proposal together, gathering the data, and evaluating the results. I maintained records of my notes, thoughts, and reflections as it related to the research study process, evaluations, and criticism. I also kept a record of any questions concerning my topic of study and any issues or tasks related to my study. I also created a research database that had two folders. One folder contains the consent forms, interview data, recordings, field notes, transcripts, and other participant responses from the interviews. The other folder would have contained all of the organizational documents that I would have collected throughout the research process. The database and files were stored on an external hard drive and also in a cloud storage system that were password protected. Storing files in the cloud is common for backing up data because it lets the researcher backup and retrieve the data from internet

accessible device (Bergman, Whittaker, & Falk, 2014). I stored the external drive, organizational documents, and any field notes locked in a filing cabinet in my office that only I have access to. I will keep the secured files containing the research data for a 5-year period. After the 5 years has passed, all files will be erased, hard copies shredded, and hard drives destroyed.

I implemented an organized system for processing, tracking, and handling the interview data. Some of the more important components when carrying out qualitative research are choosing participants, analyzing the data, and ensuring rigor and quality of the research (Baškarada, 2014; Elo et al., 2014; Paulus, Woods, Atkins, & Macklin, 2015). Handling the large volumes of data can be overwhelming to some researchers. An important decision when doing qualitative research is selecting the appropriate software program which will assist with increasing rigor in research (Sotiriadou, Brouwers, & Le, 2014). I used the NVivo program to help me organize the research data. NVivo is a software program used to assist researchers with the organization, evaluation, and sharing of the data collected from observations, focus groups, interviews, and literature reviews (Castleberry, 2014; Houghton et al., 2015; Paulus et al., 2015). The NVivo program is an easy-to-use tool that allows users to organize the research data they collected by type (Castleberry, 2014; Houghton et al., 2015; Zamawe, 2015). The NVivo program supports the synthesis and management of the qualitative data allowing researchers to quickly pull data and categorize, sort, browse, interpret, and code the records (Zamawe, 2015). The NVivo software program was the right fit for because researchers can upload and catalogue the data so it can be coded into themes (Hu et al., 2015; Rohatinsky, Jahner, &

Jahner, 2016; Sotiriadou, Brouwers, & Le, 2014). I imported files from my doctoral research study into the NVivo program. The files contained the data I collected from the audio recordings of the interviews. Furthermore, the database contained different formats that included audio recorded data, interpreted interview files, member checked files, and notes from the field notes.

The data collected throughout a research study must be protected and the researcher should have a way to ensure that the participants' identities remain private and that information will not be revealed (Morse & Coulehan, 2015; Kaiser, 2009). I transferred every interview transcript into a Microsoft Word document. These documents were renamed with a pseudonym code that represented the participant and the interview date. This helped me to preserve the data's integrity. The research data was stored on a password protected external flash drive and backed up to the password protected cloud system to prevent a loss of data which could occur as a result of loss of external drive or data corruption. I keep the external drive in a locked filing cabinet that only I have access to. All data on the external hard drive and in the cloud, system will be erased and the external hard drive will be destroyed after a period of five years.

Data Analysis Technique

The data analysis also included transcribing data and the coding of documentation in order to maintain the participants' confidentiality. The main strength as it relates to data in supporting case studies is in the numerous sources available that help form a supportive and relevant conclusion (Baškarada, 2014). The data being collected in my study was reconciled through participant interviews and field notes. Lambotte and

Meunier expressed it would be a good practice if researchers who utilize qualitative case studies would put all of their data sources together (2013). Stewart, Gapp, and Harwood suggested that transcription should occur for every data source related to the research study (2017). I transcribed each audio recording and translated the notes that focused on design strategies used to create virtual reality user interfaces.

Qualitative researchers who use a case study design usually collect their data from numerous sources by utilizing methodological triangulation (De Massis & Kotlar, 2014; Haahr, Norlyk, & Hall, 2014; Hyett, Kenny, & Dickson-Swift, 2014). To achieve methodological triangulation, I conducted telephone and Skype semi structured interviews while observing participants' tone of voice and, body language, and non-verbal signals. I opted to use methodological triangulation because as the only researcher, I did not have access to several researchers to get their outlooks. My study focused on one research study and did not deliver different views of the same data using different methods which resulted in me not needing to use theory triangulation. Methodological triangulation includes utilizing different ways of gathering information on the same issue (Carter et al., 2014). As mentioned before, I planned to collect data using organizational documents and interviews which was appropriate for the use of methodological triangulation in my study. I saved every interview transcription into a single file and stored them on a secure external hard drive that was stored in a locked filing cabinet in my office. I did not review any company documents and did not have to transcribe the data relevant to virtual reality user interface design. The recorded data was stored in a file

until it was time to perform the next phase in the process. I also reviewed my observations and transcribed my discoveries into a different file for the next phase.

As stated earlier, I used the NVivo software program to assist me with the data analyzation. NVivo can help with categorizing information and assisting researchers with establishing themes and discovering trends when coding (Rosenthal, 2016). The researcher must decide how to utilize the information and explain results so I will be sure to review the research data thoroughly. I reviewed themes to determine how they lined up with one another and how they focused on the research question. As expressed by Oliveira, Bitencourt, Santos, and Teixeira (2015), content analysis could be split into different approaches: syntactic, lexical analysis, and thematic. The analysis in my study focused on themes and the rate of recurrence for the codes associated with the concepts within my framework. I used a thematic technique for the content analysis in order to relate important themes with my conceptual framework and current studies. I used themes that I identified when reviewing the data and via the NVivo software program. An important task in getting the needed data for my study was creating interview questions that allowed me to form generalizations in the data. Using open-ended questions that start with “why” or "how" can motivate participants to give responses that include actions over a period of time and can strengthen the understanding of reasons behind the case study results (Hashemnezhad, 2015). My interview questions and the follow-up questions were created by utilizing important words like “why” and “how” to help provoke rich responses.

Reliability and Validity

Researchers attempting to ensure reliability when carrying out a qualitative study require different methods for trying to determine credibility, dependability, transferability, and confirmability. Creating data trustworthiness in qualitative research measures reliability and validity (Baškarada, 2014; Elo et al., 2014). Kruth states that validity measures how research studies what it is supposed to (2015) and reliability measures how well a study can be conducted again with the same results (De Massis & Kotlar, 2014). Determining how trustworthy a qualitative study is involves evaluating its dependability, credibility, transferability, and confirmability (Elo et al., 2014; Noble & Smith, 2015).

To increase how dependable my qualitative multiple-case study was, I (a) used data collection that included facilitating semi structured interviews; (b) managed every interview by utilizing an interview protocol; (c) utilized member checking; and (d) constantly examined things like field notes, raw data, and used products to validate data. For qualitative studies, data validity and reliability are important to create throughout the research (Houghton et al., 2015). Reliability in research relates to the degree that research results can be produced in a replicable, transferable, and transferable way (Baškarada, 2014). Reliability consist of achieving validation by coming up with the same outcomes if the study were replicated (Fusch & Ness, 2015). Qualitative research plans associate triangulation for testing the validity as shown by combining data from the different sources (Carter et al., 2014). The reliability of this study depended on how willing the participants were with providing honest and detailed responses. Ideally, the responses

should be similar or the same if the questions are asked by a researcher doing another study (Morse, 2015b). To encourage open and honest sharing and to make the participants feel comfortable, I made sure everyone understood that responses would remain confidential, that research and interview data would be kept in secure in files which would not hold any personally identifiable information, and that all information would be stored on a password enabled external hard drive that only I had access to.

Dependability is premised on the confidence and trustworthiness of a research study. I improved dependability by explaining the research process and chosen design with rich descriptions and then discussed the instruments I used for collecting data and analyzing the findings to make sure someone else could replicate my study. According to Anney (2014), dependability ensures that a researcher's qualitative study results stay dependable and consistent constantly over time in different settings. Dependability reveals research processes that confirm getting comparable results with comparable settings when reconstructing someone's original study (Grossoehme, 2014). I also ensured dependability by utilizing member checking to make sure data was interpreted correctly and to confirm the accuracy of the participants' transcribed experiences.

As pointed out in the section for data collection, I used member checking as a way to establish credibility. I also utilized data triangulation by collecting notes and interview data. Triangulation is the process utilized to collect several forms of data for double-checking interpretations from different sources which supports validity (Fusch & Ness, 2015). It includes observations, interview data, document review, and journal notes. These types of sources could provide different viewpoints from the data collection

process to create a better understanding. Triangulation and member checking could enhance the trustworthiness, quality control, and credibility of research studies (Anney, 2014). Member checking boosts trustworthiness and decreases errors because participants could confirm that the researcher correctly interpreted the interview data. More specifically, methodological triangulation was used with a process for classifying and evaluating the data. I addressed credibility by asking participants to not share any part of their involvement with others until the research had ended. Qualitative researchers can demonstrate credibility by delivering a summary of the interview transcripts to every participant through member checking in an effort to minimize or prevent errors (Fusch & Ness, 2015). Credibility can be seen as an approach used to assess if the study results represent a realistic clarification of the collected participant data (Savage & McIntosh, 2016; West & Moore, 2015). Credibility applies techniques that demonstrate that the findings are realistic, appear honest, and took on a complete depiction of the case under investigation (Amukugo, Jooste, & Mitonga, 2015).

My study's transferability was heightened by the rich, thick descriptions provided for the data in the analysis. I achieved transferability by using thorough detail and clear descriptions in conversations, interviews, observations, and throughout the data collection process. This allowed me to assess similar transferability of the same case in my study with comparable conditions and participants who were very much alike. In qualitative case studies, transferability could be validated by rich, full descriptions and complete process reporting taken during research study (Bokaie, Simbar, & Ardekani, 2015). Connelly (2016) expressed that transferability was being able to use the results from one

study and applying them to another and the researcher should support it by using detailed descriptions of the case and transparency of the analyzed data. Carefully constructing and using qualitative tools, reinforced by effective interviews, is important to ensure transferability. If I could produce more distinct and detailed information from this study, the better chance there was that the results could be applied to a comparable case.

I utilized member checking, data validation, and triangulation to formulate conclusions from the data collection to verify the accuracy of the information for my research study. I documented observations from the interviews and then wrote down the steps taken during each phase of my research process in a journal so that I could offer repeatable steps for any future reviewers. Moon, Brewer, Januchowski-Hartley, Adams, and Blackman (2016) added that the results in a research study could be replicated if the processes are documented. Confirmability conveys the notion that research interpretations and results are linked to the data so that it can be understood by others with no difficulty (Grieb, Eder, Smith, Calhoun, & Tandon, 2015). Confirmability also determines how well the results are supported by the data (Hjelm, Holst, Willman, Bohman, & Kristensson, 2015).

Data saturation improves the research process's quality while also making sure that information is not lost throughout the data collection process. The goal of data saturation is to ensure that no more new concepts, ideas, or themes could be reached by the researcher after conducting multiple interview sessions (Fusch & Ness, 2015; Morse, 2015b). When the participants' responses start getting repetitive and redundant, data saturation has occurred because no new information appears (Yin, 2014). I did member

checking until I determined that data saturation had happened, and no new patterns or themes emerged. I presented each participant with the chance to review the data analysis results after the interview and transcripts were completed.

Transition and Summary

Section 2 started with a restatement of the purpose of the study. It presented a comprehensive description of the role of the researcher, participants, and the target population. For this qualitative research study, the methodology selected was a case study design since it provided a rich and in-depth examination of the participants' experiences, encouraged gathering data from several sources, and adopted analysis and reports. This exploratory study adopted qualitative research that provided the best way to examine multiple data collection techniques that helped explore the case, produce the anticipated reports, themes, and codes. The research design for this study was a qualitative multiple case study. The sampling techniques used was purposeful sampling. The main ethical principles adopted for this research study were justice, beneficence, and respect for persons since they are primary ethical concerns for protecting human subjects as mentioned in the *Belmont Report* (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). In addition, Walden IRB rules and the application of ethics was considered while engaging in activities completed during the study. I gathered data using an interview protocol, which included interview questions (see Appendix C).

The data organization technique being used for the study supported secured information and data. The data analysis used a method of open coding that examined the

transcript and analyzed the data by themes by way of data reduction and an application of comparison practices to attain a complete understanding of the content. Criteria and techniques for measuring trustworthiness, reliability, and validity in this qualitative study were discussed in detail and will be implemented.

Section 3 covered the results from the research study, communicated applications for professional practice, implications for social change, recommendations for action and further research, and provided reflections and a strong concluding statement.

Section 3: Application to Professional Practice and Implications for Change

Overview of Study

The purpose of this qualitative multiple-case study was to explore design strategies of software developers who have developed quality virtual reality environment user interfaces. I interviewed and carried out member-checking with six developers working for three different organizations located in Texas. The developers I interviewed worked in different industries (e.g., video game, financial, and creative marketing), and their positions varied within their organizations. The participants had 4 to 15 years of experience in the industry, and a few (3 participants) had 1 to 4 years experience with virtual reality. I reflected on the data to understand what was involved with designing and developing virtual reality environment user interfaces. The organizations did not make any documents available for use in the study. Two of the organizations advised that they were in the middle of projects and could not release documentation as it pertained to their internal virtual reality design strategies in an effort to protect their proprietary information and client relationships. The third organization advised that given how much time and resources they had invested in developing their virtual reality design strategies, it was their legal department's stance to take the necessary steps to protect the information. For these reasons, all three organizations declined to approve the use of their documentation.

I placed participants into groups based on their current industry, with three participants being in the creative marketing industry, two participants being in the financial industry, and one participant being in the video game industry. I also placed

participants into two categories based on years experience working with virtual reality. Three participants had 1 to 2 years of experience, and three participants had 3 years or more experience. The data analysis yielded five key strategies for designing quality virtual reality environment user interfaces and showed some variance in the strategies based on context. I organized the themes by key theme and subthemes connected to the key theme. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Presentation of the Findings

The research question used for my study was, What design strategies are used by IT software developers to improve the quality of the virtual reality environment's user interface? It is important to share that the study participants had different thoughts on design best practices. All of the participants mentioned that design best practices differ depending on what is being developed while three participants indicated that best practices are still evolving for virtual reality technology because it is so new and best practices can only be utilized as guidelines instead of as a success model. The concept of using best practices as guiding principles shaped the findings as the data collected showed that some strategies developers use to improve the quality of virtual reality environment user interfaces were not necessarily utilized to apply design best practices.

Theme 1: Focus on Simple Design

Focusing on creating a simple design was one of the key themes I found in the study. The participants indicated the notion that developers should focus on creating a simple and clean interface that does not clutter the screen with too many options. Three

of the participants indicated that the user interface background should be clean and one color so that data are visible to the user. Three participants also mentioned that the right amount of options should be present in the interface versus presenting every single choice a user can make at one time. Five of the participants noted that users have gotten confused and become paralyzed when they do not know what to do while interacting with the user interface within a virtual reality environment.

The participants indicated that creating a simple interface is an important strategy for them that involves different elements. When the participants were asked which design strategies they used when designing virtual reality user interfaces to ensure that they were easy to use for the majority of the users, all six participants acknowledged that virtual reality user interfaces have perception and attention challenges, and five of them provided responses that indicated that perception, attention, and understanding how users process information in virtual reality play a key role in developing the user interfaces. Five of the six participants specified that addressing perception and attention challenges was more of a design element. Only one participant provided no input into this area of the design process. The tactic for providing solutions to the perception and attention challenges and evaluating their success differed between the participants. However, five of the participants indicated that when designing virtual reality user interfaces, designers must be deliberate and intentional in order to attract the users' attention. One participant mentioned that they addressed the perception and attention challenges by displaying arrows or cursors at a comfortable gaze level to redirect the user's attention to the user interface. Two participants indicated that users' reactions are quicker with audio cues

than with visual ones, so they make sure to focus on the audio component to help redirect the user's attention to what they want them to look at. Two participants indicated that gaze-based interaction is a strategy they used to provide the user with the feeling that they can control objects within the virtual reality user interface with their mind therefore translating into an intense immersion and less confusing experience. One of the two participants also indicated that the gaze-based interaction strategy has worked very well for their virtual reality user interfaces because it gives the user the ability to actually trigger different components of the experience.

Current literature is in line with the information the participants supplied. However, at this time, there is a limited number of scholarly studies on how developers address perception and attention challenges in their virtual reality user interfaces. Studies do exist on the effects of the virtual reality user interfaces on users' cognition and how existing virtual reality environment user interfaces create cognitive overload challenges while navigating through the simulation. Segkouli et. al (2015) and Kruijff and Riecke (2017) both mentioned some of the effects that virtual reality user interfaces can have on a user's cognition. Per Armougum et al. (2019) and Weibel, David, and Wissmath (2011), flow in a virtual reality environment could be defined as the state where a user is immersed or involved in an activity. This notion is in line with Alcañiz et al. (2019), who noted that one of the main challenges for developers is creating user interfaces that have a balance between being simple yet familiar, keeping the users' interest, and not causing discomfort. Alcañiz et al. also noted that the interfaces should not be so simple that they turn out to be uninteresting for advanced users causing them to leave the environment and

not too overwhelming where others leave the environment. That thought was a constant view with all six participants. The participant answers did not vary regarding how the flow is created as all of the participants stated that the goal when trying to create virtual reality user interfaces was to leverage best practices used with mobile or computer experiences because they are familiar. They did this in order to cut down on the time that it takes for users to understand the technology. All six participants indicated that applying things that are familiar to users helps provide a comfort level and intuitive expectation of how they should interact within the virtual reality environment. Three participants mentioned that developers have to find the right balance between applying patterns that are familiar to users from their uses of other applications, which in turn helps them understand what to do in the environment. The other three participants indicated that keeping the user interface simple and using familiarity makes navigation easier because users can easily recognize objects that they have seen in other applications, which makes them feel more comfortable in the virtual reality environment. The concept of familiarity is mentioned in some literature as a design technique that helps users become more comfortable with the user interface and increases learnability based upon the skill level of the user (Reski & Alissandrakis, 2019).

The literature reviewed since the start of this study is in line with earlier literature and participant responses, but a thorough exploration of existing literature once more confirmed there was limited research about the design strategies developers use to address cognitive aspects within the virtual reality user interface. The creation of virtual reality user interfaces is an innovative and fairly understudied area and research is

continuously being conducted on which strategies best govern the construction of quality user interfaces (Choi et al., 2015). Although they do not discuss how to handle solving for challenges with cognition and when and how to apply certain design features regarding user interfaces, Górski et al., (2016), discussed different frameworks for designing a user experience in virtual reality applications and provides an examination of interaction design elements for pathways and audiences. Shin (2018) added to the discussion with asserting that flow has an importance when designing for the virtual reality user interfaces, adding that the difficulty comes into play when developers combine different elements of interaction together. Three participants stated that flow in the development of virtual reality user interfaces referred to how activities in a process were designed to be executed. Bian et al. (2016) also mentioned that flow referred to a situation where a user is fully immersed in the interactions within a virtual reality environment with a profound feeling of control. According to the participants, flow is important. Four participants added that the developers present the flows to the stakeholders who are going to be using the virtual reality user interface in order to validate that the way the flow is divided looks and makes sense to them.

Even though the challenges of creating simple virtual reality user interfaces and addressing perception and attention elements is studied by earlier and current literature, scholarly literature about design strategies that developers use to solve for these challenges is scarce. This is in line with information provided by study participants who indicated that there is very little guidance in this area of focus for them. One of the key concerns for developers when designing virtual reality user interfaces is addressing

perception and attention elements to ensure the type of flow so users continue to navigate through environment. The constructionist and constructivist frameworks again appear to deliver the proper framework for this theme because both allow construction by developers and unrestricted exploration by users. Within virtual reality learning environments, users could interact with objects and content as if they were in the real world.

Simplicity is positively associated to perceived ease of use and the user's intent to use (Ozturk et al., 2016). Furthermore, for this theme and as mentioned by the study participants and as found in the literary texts, flow is key because when properly designed, the user interface will make a user feel more comfortable and at ease as they navigate through the environment. This causes a reduction in levels of frustration and discomfort when moving around in the environment and subsequently greater understanding and intent to explore more in the virtual reality environment. Table 1 shows participants' references to the simple design theme and subthemes.

Table 1

Theme of Focusing on Simple Design

	Participant	
Key theme	Count	References
Focusing on Simple Design	6	9
Subtheme		
Clean Interface	4	13
Familiarity	6	20
Less Physicality	3	5
Audio and Visual Balance	5	21

Note. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Theme 2: Defining the Development Process

The next theme that appeared in the research is that developers followed standards when developing the virtual reality user interfaces. Table 2 lists subthemes and references as they pertain to this key theme. All of the participants expressed that the process starts with collecting requirements from the stakeholders who could include business users, executive leadership, developers, programmers, and designers. One participant advised that this could also include getting funding and determining the type of virtual reality environment user interface. Five of the participants stated that they use the Agile systems development life cycle method in that they are using iterations by creating the virtual reality user interfaces by modifications in order to adapt to the development process and satisfy their customers' needs by giving them results quickly. The Agile method includes designing, developing, testing, deploying, and then going over the product approaches. The Agile method is used in their development process because the requirements are sometimes changed to improve productivity and satisfy the needs of the customer. Three of the participants stated they use this method because they have limited skilled resources in virtual reality, and it allows them to use them wisely to get ahead of their competition. One participant stated that their process involves collecting requirements, figuring out the range for the project, determining how many resources are needed which would include designers, programmers or developers, costs, and scheduling for the project. All of the participants indicated that defining the development process is important because it sets the tone for establishing quality and for the virtual reality user interface construction due to the important decisions made throughout this stage. The developers then moved into

the phase where they created a prototype and consistent with three participants, this phase was where most of the developers' time was spent. During this stage, developers made user interface components and iterate the development of the project, moving from simple to intricate components. All of the participants mentioned that during this stage they develop the design and show it to the stakeholders. They then bring in users to test the content to let them know where they are succeeding. The goal is to test the product very quickly in order to learn quickly what is working and what is not. Finding issues in the user interface is also an important part in the process. The activity mentioned the most by participants was testing. Testing was considered the most important piece for determining quality because the virtual reality user interface's successful testing rests heavily on it being easy to understand and navigate around, but also causing less frustrating and discomfort to the user. Another characteristic shared by the participants regarding the development process is that it is very iterative. The development process involved repeating prior tasks until the existing task met the right standards.

The accumulation of literature collected since the beginning of this study is in line with earlier literature regarding using a software design processes for development of virtual reality user interface. Software design and development is detailed largely by numerous scholars and an investigation of the advantages and disadvantages of various methods is outside this study's scope. However, it is worth outlining the main methods that seem to denote the responses from participant interviews. Mohino et al. (2019) studied the agile software development life cycle and it consists of the following key stages: gathering requirements, analysis, design, coding, and testing to ensure that all

stages are complete and after that it is delivered to the customer. One of the main avenues for developing software across the years was use of the agile method because development occurs in stages that are defined clearly with milestones that have already been established. Every task and activity must be completed prior to a release happening and then it moves to the next phase once the milestones are completed (Heeager & Nielsen, 2018). Gill et al. (2016) indicated that the virtual reality business has accepted software development methods and reiteration attributes in agile design. In my case study, each participant shared that the iterative process used when developing their virtual reality user interfaces was in line with the agile programming model defined by Kupiainen et al. (2015) who defined the agile method as a practice that might move from the last development phases to the design phase, if needed, is contingent on the tester and stakeholder responses. Kupiainen et al. (2015) indicated the virtual reality development process is not straight forward since a lot of the developers' actions depend on the users' feedback.

Most of the feedback in the development process is received during the testing phase which has been acknowledged in the literature that exists as an essential piece in the development of software (Deak, Stalhane, & Sindre, 2016). Every participant was in agreement that feedback was important to their work and whether the product was a success depended on it. The participants stated that as the user interface was being developed, it was constantly tested. The developers did not pause for a particular part to be finished prior to testing what was already completed. As soon as an element or component of the user interface was completed, it was run through a testing cycle. One

participant stressed this when he advised that they bring users in and have them interact with the interface without any direction to see if they can figure out what to do themselves and if it makes sense to them. Zachariah (2015) noted that testing the software is an important part in the software development process, but thorough testing still might not be adequate enough to detect every problem. This is in line with the results from my study. One participant stressed that no virtual reality user interface design is ever really complete since something always needs to be finished or something that was not addressed by the developers. All six participants shared that issues discovered in testing could bring about slight changes that pinpoint a certain issue or in bigger changes that could result in reverting to an earlier stage, however two participants admitted that it did not occur often.

Mendes et al. (2017) defined the practice of building virtual reality environments as iterative and mentioned that the agile method for building the user interfaces was more fitting. Mendes et al. (2017) also mentioned that the agile method is now very common in the development of virtual reality environments and offers input throughout each phase of the development process and fast changes. Yet, Ahmad et al (2017) mentioned that an agile approach could lead to extended development periods when the outcome is not defined well. This issue was raised by one participant in the study. All six participants added that understanding the scope of the project in the beginning is important to make sure the project could be finished. Two participants mentioned the importance of understanding the scope because it effects project costs and decisions.

Testing of the user interfaces remains a substantial area of development in the existing literature. Riecke et al. (2018) touched on how testing virtual reality user interfaces has become a really costly and complex portion of the software development life cycle. Schlueter et al. (2017) asserted that the test phase could help with identifying issues ahead of schedule and it is important since the more an issue exists within a process, the more expensive it could be to fix it once it is identified. Two participants indicated that this was why they tested every time there was an element or object added or changed in the user interface.

This theme also aligns with the constructionist and constructivist frameworks. The results of the study support the participants in my study are motivated to facilitate the construction and design of responsible products while creating an enjoyable experience that is liked by the virtual reality community. Constructing and designing responsible products, which includes thorough testing, is directly aligned with learning of workable designs by considering various human initiated and controlled impacts on the virtual environment in design activities. This has a positive effect on the users' attitudes towards utilizing the new technology (Khan et al., 2017). The constructivist framework would also apply here since it takes into account that reality is built on collective experiences and the results are formed through constructions and consensus.

A well-designed user interface product could help reduce the level of frustration and discomfort a user might experience when interacting within the virtual reality environment because they would have less stress from not knowing how to move around in the user interface and reduced chances of the environment malfunctioning as a result of

bugs. Lessening the apprehension of users when interacting with the user interface is equally associated with ease of use and their intentions to immerse themselves (Schlueter et al., 2017). The participants were consistent with the idea that they focus on making things fun to help ensure that the users have a good experience and will choose their application.

Table 2

Theme of Defining the Development Process

	Participant	
Key theme	Count	References
Defining the Development Process	6	10
Subtheme		
Gathering Requirements	6	12
Agile Method	5	7
Costs	1	3
Iterations	6	33

Note. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Theme 3: Focusing on Customer/User Satisfaction

Putting focus on satisfying the customer was another key theme. The idea is that developers should place more attention to developing software to satisfy the customer's needs. Activities vary from taking part in requirements gathering conversations to making sure that the solutions are actually available and practical in order to create a positive user experience. The activities are important because delivering virtual reality user interface solutions is a complex task. Sometimes designers create designs to include quality, yet problems arise in development that require modifications to the design. In these types of

situations, decisions must be made that focus on minimizing costs, getting the customer their product, all while satisfying their needs at the same time. Some of the ways that developers could reduce costs are by quickly delivering solutions, reducing the complexity of the solution, and streamlining the resolution of the issue are a few measures that could save costs. All six participants advised that satisfying the customer is their main focus for improving quality. Four of the six participants mentioned that providing customers with a solution is a way to focus on their satisfaction. They also revealed that they sometimes participate in defining business requirement in order to understand the needs of their stakeholders. Similarly, one of the six participants indicated that minimizing the lifecycle costs is also considered a way to focus on satisfying the customer. The one participant stated that fixing and delivering issues fast and then deciding if to postpone implementation for certain design elements based off of the risk analysis are additional measures to minimize costs.

The focus on satisfying the customer aligns well with the constructivist and constructionist framework because customer satisfaction could be described as the customer's negative or positive feelings towards the value of utilizing a service in a certain situation (Ardabili & Daryani, 2012). That feeling could be a response to a specific situation or a general reaction to a bunch of experiences. According to Ardabili and Daryani (2012), customer satisfaction is theorized with transaction-specific undertones and is based on a customer's experience. One participant indicated that they focused on the user and experience and customers' journey by using the user feedback to substantiate any changes to the user interface design and to use. The literature and data

both support various aspects of concentrating on satisfying the customer. Two participants indicated that the solutions have to be usable, the system completes the user's required functions, and that the system is available whenever the user needs it.

Two participants shared that they were sometimes involved in validating the requirements. Another participant advised that developers are sometimes involved in making sure that stakeholders have a good understanding of the requirements. Another participant indicated that sometimes developers have to validate the non-functional and functional requirements. From the literature, Cleland-Huang et al. (2014) upheld this noting that putting focus on the functional requirements and disregarding the nonfunctional requirements could lead to unsuccessful solutions. Table 3 shows participants' references to the focusing on customer/user satisfaction theme and subthemes.

Table 3

Theme of Focusing on Customer/User Satisfaction

	Participant	
Key theme	Count	References
Focusing on Customer/User Satisfaction	6	13
Subtheme		
Understand Needs	6	25
Deliver Product	6	19
Minimize Cost	1	5

Note. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Theme 4: Focus on Delivering Models and Prototypes

Although focusing on quality is important, delivering tools to assist developers with satisfying objectives is also key. The tools consist of proofs of concept or prototypes, models that define the solution, and a clear set of tools to help implement that product. Developers utilize models for supporting several perspectives for one solution and then use it as the foundation for other solutions. Similarly, developers also utilize prototypes for showing how a group of tools can be combined together to accomplish a goal. The level of detail that developers typically include in their prototypes differs.

Five of six participants mentioned that the delivery of prototypes is important in assisting the developers with achieving quality. Five of the participants indicated that the focus for the prototypes should be the higher-level component interactions. The prototypes should demonstrate that a concept functions properly to support a product. Two participants indicated that concept should be written out so that there is a clear understanding of what the users want, what the entire virtual reality experience looks like, and how everything is connected. Another participant added that providing prototypes really creates a map, pathways, or guidance for how users are going to flow through the experience.

The delivery of models and prototypes aligns directly with the constructionist and constructivist framework in that all stakeholders, including users, are included in each aspect of the design and development process. The users take part in the providing nonstop feedback about the design, not as spectators. The shared knowledge gained from participant feedback could be applied to create more meaningful guidance. Wiburg et al.

(2017) noted that using prototypes is common and each component is as similar to the production model as can be. Five of the six participants indicated that they have used prototypes as outlines for a successful implementation. In the literature, Russo et al. (2018) discussed how prototypes have certain usages in the product lifecycles and supported using models while enhancing the product quality. Developers utilize prototypes for specifying the direction of the product and not to totally represent the finished product. Rayna and Striukova (2016) mentioned the idea that are prototypes not always signifying the final result from production as a result of mandatory and unanticipated variations in production.

Delivery of the prototypes should be on time in order to carry the highest value. In the literature, Rayna and Striukova (2016) revealed that delivery of prototypes should be done early on in the process in order to validate if the solution meets the quality goals. On top of prototypes, developers could deliver wireframes, diagrams, and other specifications to validate information with stakeholders. From the literature, Ivan et al. (2015) talked about projects where developers enhanced quality through delivering illustrations and rapidly constructing prototypes in order to corroborate their concepts with the stakeholders, validate any assumptions, and to refine specifications. Table 4 shows participants' references to the focusing on delivering models and prototypes theme and subthemes.

Table 4

Theme of Focusing on Delivering Models and Prototypes

	Participant	
Key theme	Count	References

Focus on Delivering Models and Prototypes	6	7
Subtheme		
Prove the Concept	5	4
Focus on High-Level Interactions	3	4

Note. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Theme 5: Focusing on Feedback

Feedback to the developers is essential when trying to create a virtual reality application with a quality user interface. Each participant in this study mentioned that this aspect was a key portion of their development process. The developers try to get the feedback early on in the process from different sources. All of the six participants stated that developers use testing as a key approach to receiving feedback. Feedback drives a lot of the product development decisions from design to production. Three participants indicated that the feedback received, drives current and future development and could have a big impact on whether the virtual reality user interface product is successful or a failure.

Previous literature indicates the key role of feedback in the process of developing virtual reality user interfaces. According to Shi et al. (2019), reviews of products could affect the overall path that a company takes when determining whether or not to stay in the existing field or market. As stated by the participants in this study, feedback from different stakeholders could quickly make or break a product if negative feedback is provided. Three participants explained that their process involves allowing trusted users and family and friends to test out the virtual reality user interfaces in order to provide honest feedback without risking the organization’s reputation and deploying the product

or experience into the larger marketplace that others would not see favorably. Four participants advised that developers typically view success based on if the users enjoy the experience and if they report no discomfort or other issues. Kim et al. (2019) indicated feedback is desired by developers and is considered an important determining factor for measuring success.

According to Ahmad et al. (2017), receiving feedback serves an important role throughout each phase in the development process. All of the participants were in agreement as they indicated they sought feedback from users or stakeholders as soon as possible. What was important, as stated by the six participants, was to recruit users who were not acquainted with virtual reality environments and have them test it out. The idea is to bring users in and have them interact with the interface without direction to see if they can figure out what to do by themselves and if the experience makes sense to them.

The study's findings demonstrate how the concepts associated with the constructionist and constructivist frameworks directly relate to this theme. The process users follow to test and provide feedback within a virtual reality environment transforms the traditional method of providing feedback via an email or survey into an engaging and constructivist learning experience. As Wu et al. (2019) indicated, the learning comes from composing and answering questions and from assessing performance within the environment. In this theme, the developers constantly stress how important it is to create a simple and fun virtual reality user interface that meets the user's expectations and do not cause discomfort. As the developers mentioned, the feedback received regarding how well the user interface is perceived determines the type of changes that need to be

updated during the development process on top of future directions of virtual reality user interface projects. Table 5 shows participants' references to the focusing on feedback theme and subthemes.

Table 5

Theme of Focusing on Feedback

	Participant	
Key theme	Count	References
Focusing on Feedback	6	20
Subtheme		
User Interaction	6	12
Testing Phase	6	15
Pre-Implementation	6	9
Evaluation Process	4	10

Note. The reference counts are related to the assignment to the theme key words. A reference might be related to one or more themes within the same reference.

Applications to Professional Practice

The apparent lack of quality design strategies used by developers in the development of virtual reality environment user interfaces was the specific IT problem that was used as the foundation for the research. The participants in the study provided strategies that developers involved in virtual reality user interface development could use to make usability results better. The participants' thoughts on virtual reality user interface design ranged from users' own aspects to very technical elements, that represent different strategies to meet the expected user outcomes.

The challenges related to creating quality virtual reality user interfaces in an aggressive market have grown throughout the years and developers are discovering how difficult it is to create user interfaces that prevail. I sought to explore design strategies

that developers used to conquer the challenges by speaking with developers who have successfully implemented quality virtual reality user interfaces. Virtual reality applications have flooded quite a few areas in people's daily lives, regardless of if they actually immerse themselves in a virtual world. The billion-dollar virtual reality industry keeps growing at a fast pace and developing quality virtual reality user interfaces to have a fighting chance in the market requires substantial time, money, and resources. Small organizations that lack resources or means to distribute their product have difficulties with getting their applications in front of users (Park et al., 2018). Payne and Steirer (2014) also mentioned that developers need thorough design strategies that will support the rising and fluctuating number of users in this industry in order to do well. It is important for organizations to apply design strategies that have focus and direction if they wish to be competitive in the market and create a virtual reality user interface that may impact an important area within our society.

An organization's ability to design quality virtual reality user interfaces could be a huge task and the study's results might be utilized to make a guide for those undertakings. As newer developers get into the virtual reality industry, the study results establish that if they wish to create quality products, they should come into alignment with a virtual reality user interface developers who already have a history of creating quality user interfaces and could offer direction due to the small success rate of virtual reality developers. The study participants were members of a smaller team within their organizations, but were involved in the efforts directed by several developers and designers. This permitted developers to mainly give their attention to constructing code

and visuals for the user interfaces without being concerned about complex decisions that must be made and reproduction pieces once guidance is provided from leadership.

Something to be considered that came from the research is that developers may not have final approval on their user interface prior to it being rolled out. The developers typically ensure that the user interfaces meet internal standards before rolling it out. Developers have to make modifications to the code and do iterations until the product meets standards or the virtual reality application would not succeed in the market.

The results of the study are noteworthy because they reveal some strategies that developers could utilize to create quality virtual reality user interfaces. The developers covered strategies for handling the design of the user interface, the testing process, in addition to how important obtaining feedback is regarding the quality and success level for their product. My study's results are reinforced by existing literature on virtual reality environment development. The participants who supplied this data for my study were members from three different organizations that are rapidly expanding as they are continuously securing newer virtual reality projects. They provided information that could help other organizations understand the relationship between simple designs and quality user interfaces, the importance of testing and delivering prototypes to stakeholders, the importance of using a defined process, and how important it is to incorporate feedback throughout every level of the process.

Implications for Social Change

A lot of data exists concerning how virtual reality user interfaces impact society. Some studies focus on how the user interfaces cause confusing, frustration, and

discomfort for users. Furthermore, a common issue has been whether virtual reality user interfaces have a positive or negative impact on a user's perception and ability to comprehend while immersed in a virtual world. This study did not address those issues directly as the main focus, but the results reveal some understanding into how decisions are made during the process that influences how developers might handle these challenges.

As the virtual reality industry continues to evolve, users will more than likely be drawn to the applications for a variety of reasons and will need quality user interfaces in order to successfully explore and immerse themselves in the virtual reality worlds. The results from this research might provide strategies that could benefit software and game developers and society as it pertains to implementing virtual reality user interfaces that are simple and easy to use and that do not cause physical discomfort. Further dialogue on the topic of how virtual reality user interfaces physically and mentally impact users is outside this study's scope as I clarify in the recommendations for further study section.

Recommendations for Action

The main stakeholders for this study consisted of prospective virtual reality developers and individuals who deliver guidance and training for developing virtual reality user interfaces. It is imperative that developers in the future know that the virtual reality industry is made up of organizations of various sizes. As suggested from this study's results, unless developers work alone, they generally work with and get some direction from a designer. This connection might have developed out of need as a result of what it requires to reach success financially in this industry. The virtual reality

industry has barriers which include high developmental costs and possibly lower revenue from the finished application (Laurell et al., 2019). The study's results reveal that the developers who have been successful are cognizant of and know the relationships between the designer and developer and focus on ensuring that they attain the designer's goals and industry standards. The results also reveal that some developers look at finances as a factor when measuring the success of their virtual reality user interface as developers create user interfaces that they want to be easy to use and fun for users first and considering revenue as lesser goal.

In an effort to make contact with new developers, my recommendation for contacting this group of individuals consists of distributing an announcement to the leadership teams of departments that offer instruction for virtual reality developers at local educational institutions and organizations to inform them of the completion of my study and where a copy can be obtained. I will make available to them a summary of my study together with instructions on how they could get a duplicate of the complete study if they wanted to review it. Additionally, I can connect with some smaller businesses here in San Antonio, Texas to provide no-cost educational forums for small companies who are involved with developing virtual reality applications.

Recommendations for Further Study

The area of focus for this study was determining the design strategies utilized by software developers to create quality virtual reality user interfaces. This qualitative study focused on collecting data from participants from three organizations that are involved in developing virtual reality applications. One of the main findings was that developers

typically get designs and direction from the designer. As a result, a lot of the developers mentioned in the interviews that the content on the user interface depended on the context of the virtual reality environment and what the customer and designer desired. If someone wants conclusive answers about the process of how to determine which content is essential in a virtual reality user interface, then it would be sensible to contemplate conducting the study another time to include designers who provide direction to the developers. Doing this could provide further understanding on the topic since data from both designers and developers would be available.

Testing virtual reality user interfaces was revealed to be an important area by each participant. The process for testing was specified as being iterative and exhaustive but at no time was it really complete. The developers started testing as soon as they had the viable code and continued to test until it was time to release the virtual reality application. Feedback is then received from users after production and changes are made based on that. The tests performed on the virtual reality user interface could offer an extension to the study. According to the participants, testing is done by the stakeholders, users, and developers. They all have certain items to look at during the tests, but the ultimate goal for all is to have a quality product that is successfully created. An evaluation of different processes used for testing from each respective group might offer further valuable information about what is needed to create quality virtual reality user interfaces and could assist the newer developers when they get into virtual reality user interface development.

Finally, the study was geographically limited to organizations who develop virtual reality applications in and around the San Antonio area in Texas. The development of

virtual reality applications is a huge business that consists of companies varying in size. A recommendation for further study would be to expand this study to consider developers from other areas across the world.

Reflections

As I started this journey, it was done with the intention of getting a greater understanding of how to develop a quality virtual reality user interface. I started playing with virtual reality video games just a few years ago. Video games have changed from the 2D environments and now consist of very intricate and realistic looking 3D interfaces. The game interfaces have transformed considerably from the stationary screens to interfaces that have backgrounds and graphics that provide users with options that allow them to immerse themselves and interact in the environment like they are really there. As I immersed myself into the virtual reality environments, I also started to think about the effect that virtual reality games had on users – both mentally and physically. Although the focus of this study is not pointed at that issue, understanding what is needed to develop a quality virtual reality user interface has undoubtedly helped me gain a better understanding of the overall effect that virtual reality experiences can have on users.

My personal bias in this study can be easily explained. I play virtual reality video games and immerse myself into the virtual worlds. As a user, I have not experienced any discomfort and sickness from the virtual reality user interfaces, nor have I experienced a user interface with issues. My bias was also influenced because I have witnessed quite a few users who I personally know play virtual reality games where they are immersed into a virtual world and none of them experienced any issues with the user interface or with

discomfort and sickness. During the research, I made an effort to stay aware of my personal bias since it may have impacted the way I engaged with participants in the study and how the review of current literature was handled. I created open-ended semi structured interview questions and asked the participants questions during the interviews in order to get their views and to cause an honest and open conversation without being influence by me. Therefore, the information I collected was not influenced by my personal opinions or thoughts as it pertained to the development process for virtual reality user interfaces. Furthermore, the literature found was divided evenly on the issue which allowed me to distribute information without inserting my own feelings. So, even though I was certainly biased against the idea of virtual reality user interfaces causing physical discomfort, my research approaches helped me concentrate on the research question and to summarize my findings in a way that was not biased. I gained a great bit of knowledge during this journey. The results of this study helped me with identifying important concepts used by some developers as it relates to creating virtual reality user interfaces and it expanded my understanding of the technical and design processes that are followed. My feelings are that I could answer the research question and begin an exchange of ideas that would lead to better understanding if research is conducted on this topic in the future.

In addition, the literature found provided a good understanding in various areas. I discovered that there is a diverse way of thinking when it comes to the impact that virtual reality user interfaces have on users' physical and mental state. I also realized that huge gaps in knowledge continue to exist since a lot of the research studies had limited

information in these areas. I discovered from talking with the study participants that the creation of quality virtual reality user interfaces was more focused on making it simple, easy to understand, and comfortable for users. The developers value the feedback provided by users and stakeholders in order to help them develop quality virtual reality user interfaces. The developers spend a lot of time working to integrate that feedback into the end product and they will continuously make modifications until the user interface meets standards.

Summary and Study Conclusions

Insight into the strategies utilized when developing virtual reality user interfaces might help individuals realize the level of intricacy involved from beginning to the final product. A developer could hold different roles within the process; however, unless she or he is a member of a small team consisting of two or three people, then the developer role is devoted to a particular aspect of developing the user interface and not on making the decisions. The majority of literature located on the topic was limited since a lot of the articles were inclined to allude to the development team as being only the developers rather than a technical group who perform the work based on direction from the stakeholders or designer. Even though the participants in this study were part of a smaller development team, the developers were had specific roles even though some participants revealed that they were could perform other responsibilities if needed. Key decisions made during a project should result in better efficiency and experience for users as soon as the project is finished. The results from the literature and participants support the idea that creating quality virtual reality user interfaces is a multifaceted effort that has a lot of

changing elements. As the virtual reality industry grows and evolves, the amount of complexity involved will likely increase. There are things that stay consistent and should be followed by existing or future developers. Some of those things include beginning with a good understanding of the scope of the project and goals, adhering to a standardized plan, thorough testing, and taking and incorporating feedback at any and every phase during the process. Success is hard, and a lot of smaller virtual reality user interface applications fail to attain success financially. Although developing virtual reality applications could be a rewarding experience, developers should define for themselves precisely what they consider to be a successful quality application.

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Appendix A: Letter of Cooperation

DATE

Dear Sir or Madam,

My name is Jennifer Maple. I am working on my doctorate degree at Walden University and am conducting a study titled “Design Strategies Used to Improve the Quality of Virtual Reality Environment User Interfaces”, as part of the requirements for obtaining a Doctor of Information Technology degree. My study will explore strategies that software developers in Texas use when designing virtual reality environment user interfaces.

Your company has been chosen as a likely contributor to this study based on your organization’s knowledge and professional role in virtual reality software development in Texas. For this study, I will be requesting to meet with some of your employees who have at least one year of experience with virtual reality design and have strategies to develop virtual reality environment user interfaces. I will also be requesting to gather nonproprietary information about design processes.

All employee answers will be strictly confidential and will not be related to the organization, its actual name, or address. Also, every record regarding this study will remain private and any report produced from the study will exclude any identifiable information.

Employee participation in the study would involve minor risks like sharing their professional knowledge with other professionals or taking time away from their work to participate in an interview. Otherwise, there are no anticipated risks to their participating in the study. Participating in the study would not present any risk to employees’ wellbeing or safety. Some benefits of this type of study are that there is the possibility of having an impact on new innovations and having an influence in the virtual reality environments user interfaces. Successfully implementing this study would surely have a big impact on the virtual reality design industry. In addition, the study will result in positive outcomes for society because strategies to create virtual reality user interfaces will be understood.

Your organization’s involvement could make it possible to publish a research study that might bring significant social change, as well as positive outcomes for society because it could advance how other technology is used that needs easy-to-use virtual reality user interfaces.

Participation in the study is voluntary for all participants chosen. Participants can decide against participating in this study at any time or withdraw the information already provided, even if it is once the data collection process is completed, without consequences.

Please consider being a contributing organization in this study and reply to me at xxxx@waldenu.edu using the attached document as a template. You can copy and paste the below template into your email reply or simply reply with "I approve", "I am giving permission for you to carry out your study within our company", or another form of expression that clearly indicates that you are providing approval for your organization to participate in the study. Walden University's approval number for this study is 09-11-19-0370485 and it expires September 10, 2020.

Thank you very much for your consideration and time!

Sincerely,

Jennifer Maple

Walden University
Doctoral Candidate

DATE

Dear Jennifer Maple,

LETTER OF COOPERATION

I am giving permission for you to carry out your study titled "Design Strategies Used to Improve the Quality of Virtual Reality Environment User Interfaces" within our company. As part of the study, I will allow you to collect data amongst my employee(s), and perform analysis activities for your doctoral study. I authorize company documents to be shared which could include (but not limited to) design documents, emails, and reports that would offer information about strategies used to design virtual reality user interfaces. The employees can voluntarily participate if they choose to.

Your interview can be held in the employees' office or at any other location and time that is convenient to the them. We also understand that the selected location will ensure that participants have confidentiality and privacy. We recognize that withdrawal from the study can occur at any time if our situation changes.

I wish you the best with your doctoral study.

Sincerely,

Appendix B: E-mail Template for Participation Invitation

Dear Invitee,

My name is Jennifer Maple. I am a Doctor of Information Technology student at Walden University. I am requesting your participation in my doctoral research study titled: Design Strategies Used to Improve the Quality of Virtual Reality Environment User Interfaces. The intent is to evaluate information to understand design strategies to improve the quality of the virtual reality environment user interfaces. As an IT software developer with at least a year experience building virtual reality environments, you are in the perfect role to provide valuable first-hand information.

I have attached a copy of the approval I received to carry out my research and also a consent form that details the study for you to consider. If you would like to participate after reviewing the consent form, please respond to me at xxxxx@waldeu.edu with the words "I consent". Your participation will add value to my research and the results could lead to a greater understanding of design strategies for improving the quality of virtual reality environment user interfaces.

Participation is totally voluntary and there is no compensation for your participation. You can withdraw from the study at any point in time and there will be no consequences. The study is confidential and you are not required to give any personally identifying information. This study will include an interview as the primary technique for collecting data.

I can work directly with you to setup a schedule for participation that will not negatively impact your work schedule.

Sincerely,

Jennifer Maple,
Doctoral of Information Technology Candidate, Walden University
xxxx@waldeu.edu

Appendix C: Interview Protocol for Case Study

Topic: Design strategies used to improve the quality of the virtual reality environment user interface.

Sources of data collected:
___ Interviews (in-person or phone) ___ Documents
___ Company documents ___ Multimedia data ___ Observations

Interview Protocol

Date & Time		
Location		
Participant ID		
Step 1	Introduction	Thank you for your time and for participating in this interview. My name is Jennifer Maple and I am a Doctor of Information Technology candidate at Walden University.
Step 2	Purpose	The purpose of this study is to explore design strategies used by IT software developers to improve the quality of the virtual reality environment user interface.
Step 3	Describe the reason for participation	The information you provide today, both in interview responses and in any documentation or other sources you may have, will support my study in partial fulfillment of the degree of Doctor of Information Technology from Walden University.
Step 4	Describe benefit of participation	This information could add to academic and professional bodies of knowledge on quality design strategies and is geared towards IT software developers and anyone else interested in maximizing the quality of virtual reality environment user interfaces. There is no compensation of any sort associated with your participation.
Step 5	Discuss ethics	To maintain ethical standards and respect your right to privacy, I am requesting your permission to record the audio of this conversation and keep notes on this entire session starting now. Once audio recording starts, I will introduce this session using your participant ID <Participant ID> and ask you to reconfirm your permission to record and take notes on this session. Is it ok to start recording now?

	Start Recording	My name is Jennifer Maple, and I am here with <Participant ID>; today's date is <MMDDYYYY>. Would you please confirm that I have provided you with background information on this study including the purpose, the reason for your participation, benefits of participation, and that you approve of my recording and taking notes during this session?
Step 6	Discuss confidentiality	Please feel free to decline to answer any question or stop participating at any time; this is a completely voluntary session. You are free to decline to answer any individual questions or decline to provide any information if you are not comfortable providing the information. All information you provide will be treated as strictly confidential and will not be disclosed to anyone, including your employer. I request that you avoid using organizational or individual names or any indicators that could be used to identify your organization or individuals in your responses. Any names or comments that are mentioned in the interview will be removed from the transcripts and will not be included in the final report. I also request that you do not discuss your participation with anyone until the study concludes. Any information provided in any form in this session will only be used for the purpose of this study, which will be presented in composite form with data from other participants in a doctoral study that may be published. None of your responses will be presented in individual form. I will keep research records in an encrypted and password-protected format, locked in a safe for five years, after which time they will be destroyed. Only I will have access to this data during that five-year period.
Step 7	Ask if there are any questions and if they want to proceed	Do you have any questions for me before we start? If no, are you ready to proceed?

Step 8	Transition to the interview	This is a semi-structured interview that is about understanding your thoughts on the topic and questions. I have a few questions outlined for which your open and honest thoughts are appreciated. I am interested in your thoughts about these questions and ask that you not consider any prior relationship I may have with you or the topic in your responses. I may ask for more thoughts or explanations on portions of your responses. As much information as you can provide on your thoughts and perspective is greatly appreciated.
Step 9	The interview	1. What design strategies have you used to develop virtual reality environment user interfaces? 2. How does culture of users impact your design strategies to develop virtual reality environment user interfaces? 3. How does the knowledge level of users impact your design strategies for developing virtual reality environment user interfaces? 4. How do you effectively handle skill level differences to develop quality virtual reality environment user interfaces? 5. How do you create environments that are expressive and allow users to interact with the environment in meaningful ways? 6. How do you promote discovery and exploration during the virtual reality session? 7. What aspects of your design strategies contributed to a user-friendly interface for users? 8. What aspects of your design strategies ensure that the virtual reality environment user interfaces you develop will be acceptable by users? 9. What design process do you employ to ensure the virtual reality environment user interfaces are easy to use? 10. What challenges did you face when developing and implementing the strategies for designing user interfaces for virtual reality environments? 11. How did you address the challenges of developing and implementing the strategies for designing user interfaces for virtual reality environments? 12. How do you work with others in the organization to ensure there is one acceptable and coherent virtual reality environment user interface?

		13. How do you receive feedback as to whether or not your design is acceptable by users and easy-to-use? 14. Summarize or identify design strategies you use to develop virtual reality environment user interfaces that will cater to the majority of users.
Step 10	Gather any secondary data from the participant	That concludes the interview portion of the meeting. Do you have any documents, multimedia presentations, or other information with you that I can collect at this time?
Step 11	Conclusion	Thank you for your time today. To ensure I have interpreted your responses correctly, I would like to schedule a follow-up interview with you in a few days. Would that be acceptable? Is there a preferred method of communication for rescheduling? Thank you again.

Appendix D: Permissions for Use of Figures

Figure 1. A virtual reality environment design using activity theory

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From: Academic UK Non Rightslink <permissionrequest@tandf.co.uk>
Sent: Wednesday, May 13, 2020 2:49 AM
To: Jennifer Maple
Subject: RE: tham20:Orchestrating learning during implementation of a 3D virtual world

Dear Jennifer Maple,

Material requested: Figure 1 only from: 'Turkan Karakus, Ozlem Baydas, Fatma Gunay, Murat Coban & Yuksel Goktas (2016) Orchestrating learning during implementation of a 3D virtual world, New Review of Hypermedia and Multimedia, 22:4, 303-320, DOI: 10.1080/13614568.2016.1179797 '.

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From: Jennifer Maple <xxxxx@waldenu.edu>
Sent: 13 May 2020 01:04

To: Academic UK Non Rightslink <permissionrequest@tandf.co.uk>
Subject: tham20:Orchestrating learning during implementation of a 3D virtual world

Permissions Request
Contact name: Jennifer Maple
Street address: XXXXX XXXXX XXXX
Town: XXX XXXXX
Postcode/ZIP code: XXXXX
Country: USA
Contact telephone number: XXXXXX6335
Contact email address: xxxxx@waldenu.edu
Article title: Orchestrating learning during implementation of a 3D virtual world
Article DOI: 10.1080/13614568.2016.1179797
Author name: Turkan Karakus, Ozlem Baydas, Fatma Gunay, Murat Coban & Yuksel Goktas
Journal title: New Review of Hypermedia and Multimedia
Volume number: 22
Issue number: 4
Year of publication: 2016
Page number(s): 4
Are you the sole author/editor of the new publication?: Yes
Are you requesting the full article?: No
If no, please supply extract and include number of word:
If no, please supply details of figure/table: Figure 1
Name of publisher of new publication: Jennifer Maple
Title of new publication: Design Strategies for User Interfaces in Virtual Reality Environments
Course pack: No
Number of Students:
Is print:
Electronic:
E-reserve: No
Period of use:
Short loan library?: No
Thesis: Yes
To be reprinted in a new publication?: Yes
In print format: Yes
In ebook format?: Yes
ISBN:
Languages:
Distribution quantity:
Retail price:
Additional comments:

Figure 2. Technology Acceptance Model

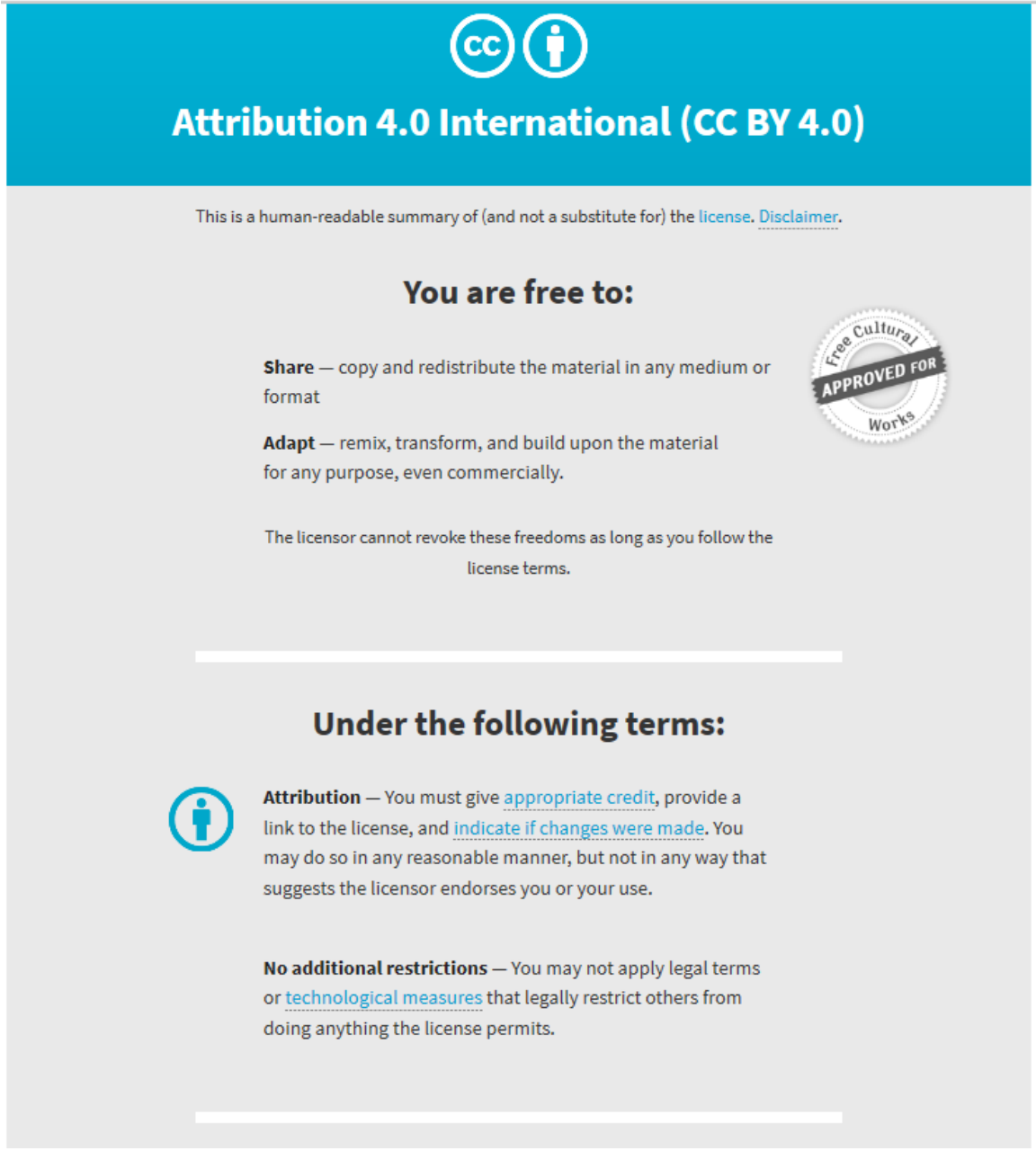

Figure 3. Steps involved in the instructional design model

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