Integrating Virtual Reality Into Scenic Design

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San Francisco State University
In partial fulfillment of
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Master of Arts

In
Theatre Arts: Design/ Technical Production

by

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Certification of Approval

I certify that I have read Integrating Virtual Reality Into Scenic Design by Alan Huang, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Theatre Arts: Design/Technical Production at San Francisco State University.

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Abstract

With the rise of Virtual Reality (VR) in games, film, and design, VR should be incorporated into the scenic design process in theatre. VR is an effectual tool that can be integrated into the scenic design process while serving as a more refined alternative when showcasing a scenic design than traditional methods. VR allows for flexibility and fluidity, thorough walkthroughs, and better perspectives. Virtual models in VR can have their colors, textures, lighting, and other details changed in real-time. In contrast, conventional methods such as a scale model can be clunky, with difficult to maneuver small pieces, and difficult to view details. Walkthroughs of a virtual set design enable all creative and production team members, such as the director, other designers, actors, carpenters, etc., to envision and highlight any details or potentially solvable problems. VR allows for a better perspective compared to viewing a scale model. Team members can walk in a virtual set design on a one-to-one scale compared to viewing a quarter-inch model – where a quarter inch equals one foot - allowing them to view the space more effectively. In this paper, I will discuss how VR will be integrated into the scenic design process while arguing why VR is a better alternative to conventional methods. The paper will have literature analysis from outside scholars on their findings with VR and an experiment to experience firsthand how effective VR is in scenic design compared to conventional methods I have been taught.
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**Introduction**

Virtual Reality (VR) has become one of the most popular technological systems in contemporary times. VR is a computer-generated environment, or simulation of three-dimensional objects, allowing the user to feel immersed in their surroundings. The user’s surroundings can be interacted with in a seemingly real or physical way using special electronic equipment, such as a helmet/headset with a screen inside, and gloves filled with sensors. VR has had a boom in popularity due to the advent of recent games that came out, such as *Beat Saber* (2018) and *Superhot VR* (2016). *Beat Saber* is a VR “rhythm game” set in a futuristic world, where users slash the beats of adrenaline-pumping music as they fly towards you. *Superhot VR* is a game where users pick up weapons to defeat enemies in front of them while dodging many bullets flying towards them - time moves only when the user moves. VR can potentially change the way we socialize and entertain ourselves, and the way we work such as diagnostics, high-risk job training like police and firemen, and surgeon and medical student training. With the capability to form or re-create a life-like reality, virtual reality can spawn many opportunities. VR is used for education and training purposes, tourism, immersion in a fantasy world, and to create new experiences in plays, musicals, and films. Considering how practical VR can be in various fields, how can VR be useful for scenic design?

I want to determine the benefits and complications VR may have in scenic design by experimenting. An experiment I will conduct is to present a past design, Marisol, and convert it into VR. Marisol is a scenic design I had designed in 2021 for the Theatre and Dance Department of San Francisco State University. The director of this play was Bruce Avery. I will then compare it to traditional methods of hand drafting and models and present it to the cast and
team of the production. By conducting this experiment, my goal is to determine if the production process becomes more coherent allowing members of the production and acting team to examine and thoroughly walk through a set design even though it is not built. Collaboration and relationships between the creative and production team can drastically improve by forming a more coherent process with VR. A researcher from the university of Washington, Dace A. Campbell says that professionals and design critics have found walkthroughs helpful and convincing during a design presentation. These professionals and critics could visualize the design more clearly than through traditional presentation methods, such as creating a model or digitalized drawings. Sometimes, the director has trouble visualizing a set through drawings or even a model. Campbell states that with the use of VR as a presentation tool, “professionals and design critics, not just clients and laypersons, are able to visualize one’s design intentions more clearly with VR than with traditional means of representation” (Campbell, Wells, 6). Drawings and models may not be enough to provide an accurate impression of the spacing and detailing of a set design. Directors may not understand how details of the design will translate to full scale, or they may not grasp how large a scenic element will be when built. Using virtual reality can help enhance the details of a set while providing spacing as one can be inside a VR model, able to walk in it as if a set was already built while noticing all the details, such as texture or pattern, on scenic elements. The contrast between viewing a physical scale model and a model in VR is captured in French-religious historian and a cultural critic Michel de Certeau’s chapter Walking in the City, from his book, The Practice of Everyday Life (1980). In it, Certeau defines two possible views we may have of an environment, either an aerial perspective (outside in) or from
the perspective of the city walker (inside out). Certeau conceptualizes aerial perspective by picturing a scene for the reader at the start of the chapter:

“Seeing Manhattan from the 110th floor of the World Trade Center. Beneath the haze stirred up by the winds, the urban island, a sea in the middle of the sea, lifts up the skyscrapers over Wall street . . . A wave of verticals. Its agitation is momentarily arrested by vision” (Certeau, 91).

This concept of an aerial perspective can be related to how we look at physical scale models, which are small. We look at the model from the outside, to understand where each scenic element is and how it appears, but we may not fully understand the details of the scenic element, just as we might not understand the detail of each building in the city if we were to stand on top of the 110th floor of the World Trade Center. On the other hand, a model in VR can be walked through, like a city walker wandering through the city. The VR model puts us inside an environment allows us to view each detail as we walk along a path of our own choosing – something many directors and other artists want from a scenic design model.

With this in mind, what are the benefits and complications of using VR in scenic design compared to other methods, and how can virtual reality be incorporated into scenic design during the pre-production process to showcase a design to a director, actors, or other designers?
Chapter 1: What is Virtual Reality (VR)?

Before discussing how VR is used in the scenic design process, let’s define what virtual reality is. Henry E. Lowood, Curator for History of Science & Technology Collections at Stanford University, and a contributor on Britannica, defines VR as, “the use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment” (Lowood). In short, VR is a virtual or simulated environment that can look like reality. However, some of us might have experienced augmented reality (AR) or seen other people, whether family or friends, use phone applications (apps) such as SnapChat or Pokémon Go. So, what is the difference between VR and AR? The Merriam-Webster Dictionary defines AR as, “an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera)” (Merriam-Webster.com Dictionary, 2022). Snapchat is a mobile messaging application used to share photos, videos, text, and drawings. Users can also add real-time special effects and sounds, change how their voice sounds, and face swap with other people. One of the most popular mobile games, Pokémon Go, is an augmented reality game you play on your phone. An author and journalist from Vox, German Lopez, describes Pokémon Go in an article. Lopez states, “In simple terms, Pokémon Go is a game that uses you ’appear’ around you (on your phone screen) so you can go and catch them. As you move around, different and more types of Pokémon will appear depending on where you are and what time it is. The idea is to encourage you to travel around the real world to catch Pokémon in the game” (Lopez).

Now that we’ve characterized the differences between VR and AR, when did VR become distinguished and how has it developed into what we define as VR today? VR dates to the early
19th century with panoramic paintings, if we decide that VR is a means of creating an illusion that we are present somewhere we are not. These enormous paintings were used to fill the viewer’s entire field of vision making them feel present in some historical moment in time. In 1838, Charles Wheatstone, an English scientist, researched on how the brain processes different two-dimensional images from each eye into a single 3D object giving the viewer a sense of depth and immersion. Wheatstone's research helped develop the View-Master Stereoscope, which was used for “virtual tourism” and was popular at the time. Virtual tourism at this time, as airplanes weren’t invented yet, allowed people who did travel abroad through sea and took photos of the environment. This created the opportunity for the people who took the photos to allow other people to virtually tour the new land. It was not until the mid-twentieth century that a product was created that was able to stimulate all five senses. Cinematographer Morton Heilig developed the Sensorama which was an arcade-style cabinet that stimulated all five senses. The Sensorama featured stereo speakers, a stereoscopic display like the View-Master Stereoscope, fans, smell generators, and a vibrating chair. All of these features were intended to immerse the user in films that were produced and edited by Heilig himself. During the next few decades, VR research begun to rapidly change and develop into what we define as virtual reality today. AR, digital flight simulators, finger-tracking gloves, and Virtuality Group Arcade Machines sprang onto the scene over the course of the 1920s to 1960s. In 1969, Myron Kruegere, a VR computer artist, developed a series of experiments containing computer-generated environments that respond to the people in it. This new technology enabled long distance communication in a responsive computer-generated environment called Videoplace. Myron Krugere’s website describes Videoplace as:
"Videoplace" consists of two rooms that could be in the same building or on the other side of the planet. When a participant enters they immediately see themselves projected on a screen in front of them, as well as the projection of anyone in the other room. Both of the participants see the same image. The participant can move their image around on the screen by moving themselves and can interact with the other participants' image as well. Either participants' image could be resized, rotated, have the color changed, and they could also interact with objects that were completely virtual (aboutmyronkrugere.com).

To put it simply, Kruegere made something that allowed two participants to see themselves. The finger-tracking gloves called “Sayre” gloves were invented by Daniel Sandin and Thomas DeFanti in 1982. The gloves were wired to a computer system and used optical sensors to detect finger movement which is a big advancement in VR technology on tracking body movements. In 1991, VR devices became accessible to the public in a range of arcade games and machines, launched by Virtuality Group. Virtuality Group was formed in 1985 as a startup called W Industries. Virtuality Group created multiple VR games and simulators and entertainment systems as the mentioned arcade machines. Players would sit on large, cushioned seats and wear VR goggles to play games with real-time stereoscopic 3D visuals. However, household ownership of VR was still out of reach as the technology was still clunky, bulky, and heavy. Finally, VR becomes apparent in the mid-2000s when Google brought "Street View" to Google maps, allowing anyone to look at any part of the world from their screen. In 2016 – 2017, VR products began flooding the market when multiple companies released versions of VR products, with Oculus Rift and HTC Vive leading the charge. Since then, VR has taken society by storm. Whether they are used for educational purposes, training, tourism, or gaming, the
technology has truly evolved from simply showing images of different parts of the world to standalone VR headsets allowing wide fields of view, hand scanning, and eye tracking.
Chapter 2: The Scenic Design Process

Before diving into how other researchers and practitioners have used VR technology in their design process, let’s define what the general scenic design process is as the process may vary between designers. A traditional early design process consists of research and forms of drawing. After thoroughly reading the script multiple times and figuring out their design concept, a designer might create a story board, or a mood board (a collage of research photos) based on certain words, phrases, and dialogue. Research can include paintings, photographs, colors, and textures where a designer can show how the research can resemble scenes of a play or how the research has resonated with them. Designers may also look at other productions to inspire them on how to form their own set design. While finding research images from outside sources, designers may begin to work on rough sketches and collages to begin forming a firmer idea on what the set looks like. At this stage in the process, the initial research is not presentable or thorough enough for a complete design in VR as there are too many variables and nothing has solidified.

After doing some research, designers may take those sketches and begin to formalize them into scenic elevations, drawings, and a white model. These elevations and drawings are drawn to show the exact look, shape, and dimensions of the size of each scenic element and how they are supposed to be placed on stage. A white model is a scale model that is mocked up quickly using paper or Bristol board to show the director the placement, the general shape and size of each scenic element. A scale model is a model that is scaled down in size to represent all the elements the designer will draw out and place onstage. Scale models come in different scales
such as a quarter of an inch to a foot or one inch to a foot. Scale, in this case, a quarter of an inch to a foot, means that if an object in the model is an eighth of an inch, then the actual size, if the object were to be built, would be six inches. There are rulers that have incorporated multiple scales, such as half-inch (½) scale or three-eighth (3/8) scale, allowing for easier real-time measurements of what an object in the model may be rather than trying to do the mental math on the spot.

Designers will continue to develop their scenic design after creating scenic elevations, drawings, and a white model to be given to the director and the scene shop to examine and begin building respectively. Designers may create color elevations and color scale models to develop the exact look they want with their sets. Color elevations are made by taking the scenic elevations and adding color and texture to them so scenic painters know what color to paint the scenic pieces. These color scale models will usually be the same size as the white model but can be larger in scale to represent all elements the designer has drawn out including all the scenic elements’ colors, textures, and placement on stage. It is at this point in the design process designers can use VR to create a 3D model instead of making a color model since most of the scenic elements and placements will be in a determined location but may change later. We will look at some examples from other researchers and practitioners who have used VR in their design process and discuss how VR has impacted their productions.

Chapter 2: Collin Huse and Jason Strom

Attempting to implement VR into the design can be problematic initially. One example of attempting to integrate VR into their theatre and opera productions was at Florida State University. Technical Director at Florida State Opera, Collin Huse, began the journey of using
VR by first creating technical drawings and animations for a play they worked on, *How I Became a Pirate*, with a 3D modeling software called *Fusion 360* is a 3D modeling software sold by *Autodesk*. From their website, *Autodesk* explains that *Fusion 360* can create 3D designs, collaborate, manage data, create toolpaths, and run simulations to validate your designs. *Autodesk* also claims that *Fusion 360* is also the tool of choice for manufacturing, machining, engineering, and industrial design experts. *Fusion 360* as used to demonstrate the moving parts of a unique set. However, Huse concluded that using *Fusion 360* was clunky to view the drawings and time-consuming. After this production, Huse began experimenting with VR viewing software such as *Sketchfab* and *EnTiTi*. *Sketchfab* is a 3D modeling platform website to publish, share, discover, buy and sell 3D, VR and AR content. It allows users to display 3D models on the web, and users are able to view these models on any mobile browser, desktop browser or VR headset. Similarly, *EnTiTi* is another 3D modeling platform allowing users to create interactive virtual and augmented reality content without any developer skills or prior experience. These two VR viewing software were used to show the set through a phone-powered VR headset. A phone-powered VR headset is using a smartphone like a Samsung or iPhone and placing it inside a VR headset. Smartphone VR allows users who are beginners to be introduced into VR with minimal risk and easy to use. By using a phone-powered VR headset, the scenic design presentation for *How I Became a Pirate* resulted in overwhelmingly positive remarks. Huse determined that “viewing the set in VR drastically improved one's sense of scale and knowledge of the set simply by walking around it as if it was on stage compared to the technical drawings and animations, he created beforehand” (Huse, Strom, 37). After experimentation, Huse's research led him to the video game industry and its use of 3D visualizers such as the
Unity game engine combined with the HTC Vive VR headset. The Unity game engine is a cross-platform game engine allowing game developers to develop 2D and 3D games as well as simulations and other experiences. The engine has been adopted by industries outside video gaming, such as film, automotive, architecture, engineering, construction, and the United States Armed Forces. The HTC Vive VR headset is one of the many headsets/helmets with a screen inside to view a simulated environment. At the same time, the VR headset is empowered with in-scale room tracking, which allows the user to walk around in a physical space while tracking their movement and transmitting the appropriate information to a screen, allowing others in the space to receive the information the user was seeing.

These new tools were implemented in Florida State University’s productions of The Servant of Two Masters, Candide, and Alcina. Strom pointed out that during a production meeting, the director of The Servant of Two Masters, David Sebren, “was able to see and fully understand the exact size and placement of objects, leading to an accurate visual understanding of the completed set” (Huse, Strom, 37). With Candide, the scenic designer, Teddy Moore, had the scenic design locked in place by the time a model rendition was made into VR. Instead of using the VR model for the designer and director to point out aspects of the design, the VR model instead was utilized by the scene shop to experience what the set was like and to start discussions about set construction. Huse and Strom noted that the carpenters in the scene shop “could see every piece of framing and better understand the assembly of each piece, but also immediately understood the size and scale of what they were building” (Huse, Strom, 37). The scene shop also utilized the VR technology for Alcina, designed by Peter Harrison, as there were numerous scenic elements that had complex structures. After using VR technology for these
three shows, Huse and Strom concluded that, “The design and production teams were able to look at a set through this immersive experience and in full scale, allowing for communication that might not otherwise exist. Experiencing and interacting with the set in scale as early as the design phase, rather than once the set is built, provided the entire design and production team with a precise understanding of space and structure” (Huse, Strom, 37). With these new tools, the director and other production members can highlight any specific discussions about the set, decide if changes are needed, or discuss how actors will interact with it, while the scene shop can use this technology to start having discussions on how complex scenic pieces will be built.

Chapter 2: Dace A. Campbell and Maxwell Wells

Maxwell Wells, a researcher and partner of Campbell at the University of Washington, and Campbell had a parallel approach to implementing VR into the design process. Campbell and Wells used VR to design an additional section to the architecture of a building that was already designed. In the earlier stages, the design was first developed with sketches and small physical models so that everyone could get a sense of the design. Campbell and Wells then transferred the sketches, model, and other specifications to formZ to begin creating 3D models. formZ is a solid and surface modeling surface while offering 2D and 3D form manipulating and sculpting capabilities. The information needed to transfer to a similar, yet unique software may have a different process, like Vectorworks. Vectorworks is a versatile, on-premise application that provides extensive 2D drafting, 3D modeling, and rendering capabilities for architectural, entertainment, and landscaping designs. When using Vectorworks, the user can draw what they need in 2D. Later, they can add dimensions and shapes to their desire in 3D. For instance, if I drew a two-foot by two-foot square in 2D, I can add height to this 2D square, thus creating a
cube. Once all the 2D drawings are converted into 3D forms and models, these 3D models can now be set inside VR technology through multiple files such as Data Interchange Format (DXF). DXF is a data file format that enables files exported from one software, like formZ, to be recognized by other similar software. Once all the files were exported out of formZ and imported inside the VR system, Campbell and Wells could adjust the frame rates and other design choices, such as color and textures.

Chapter 2: James Simpson, Bella Heesom, Donnacadh O’ Briain, Elizabeth Harper

A new work produced in 2019 at the Ovalhouse Theatre in Oval, London, Rejoicing at Her Wondrous Vulva, The Young Lady Applauded Herself (Wondrous Vulva) used AR holographic visualizations to “share the designs of the production and provide continual feedback on the development of the digital 3d model to ensure it was being built correctly” (Simpson, 220). This experiment derived from an earlier production by the Artistic Director for Ovalhouse, Owen Calvert-Lyons. Calvert-Lyons first spent some time looking at the scenic design for his production of Random Selfies using AR with the Microsoft Hololens. The Microsoft Hololens is an augmented reality (AR)/mixed reality (MR) headset. As I mentioned earlier, AR/MR differs from VR by using a real-world environment but generating perceptual information by adding sound, visual elements, or other sensory stimuli while VR is a complete virtual environment that is not real. Calvert-Lyons was able to confirm the placement of the staging and to simulate the same stage environment he had seen in mock-ups based on his experience from the experiment and play he worked on in Random Selfies. Thus, after Calvert-Lyons production, the team for Wondrous Vulva, were open and accommodating to incorporate this technology and experimental research into their design process. People involved in this
experiment included a researcher and writer, James Simpson, a writer, performer, and playwright of *Wondrous Vulva*, Bella Heesom, Director Donnacadh O’ Briain, and designer Elizabeth Harper.

Although the majority of decisions and choices were made earlier in the design process, all these members viewed the scenic design in VR at the final stages of the design to confirm the set placement and actor blocking. Simpson on Harper’s experience, “As a theatre designer, she [Harper] is used to thinking about the scenery through a model box (a scale model of the scenery) which has textures and finishes that may represent the finished product whilst not being entirely accurate” (Simpson 222). To summarize Harper’s experience when working in VR compared to using a scale model, Harper expresses that, “Although the finished product on a stage may not be entirely accurate, VR enhances the textures and finishes of a design that may not be fully visualized in a scale model” (Simpson 222). Similarly, as Simpson talked to O’Briain about his thoughts on the VR experiment, O’Briain concluded that the VR technology “was able to provide more “color and texture” to the preparation process which helped inform his directorial process in the rehearsals” (Simpson 223). Multiple scenic elements were changed because of the experience O’Briain had. O’Briain decided to move the entire set upstage a few meters. This decision was crucial as this would’ve cost many hours and would have a huge impact on lighting as they would need to rehang and refocus their lights. Another decision made as a result of the VR experience was to switch a chair out in exchange for a swing. From O’Briain’s experiences and thoughts on the technology, Simpson concluded that, “shared AR experiences support communication between team members and allowed a conversation to happen before the money had been spent on an expensive chair—something which O’Briain
expressed to Harper at the time of the conversation as a reason for bringing it up at all” (Simpson 224).

Chapter 2: Anne E. McMills

Anne E Mcmills, the head of lighting design at San Diego State University, provides to the reader multiple 3D modeling and rendering apps that are highly user-friendly and thriving in the technology market. These 3D modeling and rendering apps includes MakeVr and TiltBrush which will be described shortly. These 3D modeling and rendering apps are used more at the later stages of the design process so that the designer may create something in a one-to-one scale allowing the director and other production members to visualize all the minuscule details before building anything. One rendering app that McMills advocates for is a popular app from Google called TiltBrush which is also available through VR head-mounted displays such as the HTC Vive and Oculus. TiltBrush enables rendering in three dimensions and provides various options ranging from typical brushes to unique alternatives like painting with light or unique textures. This allows a scenic, lighting, or costume designer to quickly mockup a sketch to provide for the director. A 3D modeling app that McMills found useful in her studies and work is MakeVR. MakeVR is similar to other traditional 3D modeling apps by offering primitive geometric shapes to use as building blocks to start up a design quickly, and can scale, extrude, add, or subtract objects. These tools - scaling, extruding, adding, and subtracting - allow the user to change the shape of their object in real time. Scaling is to make one object larger or smaller while maintaining the same proportions throughout the object. Extruding is to extend or push out a surface of an object. For instance, if I push out a surface of a six-sided cube, that surface will create another cube creating a rectangular prism. Finally, adding and subtracting objects in 3D is
either adding or subtracting objects in your environment, or it could be adding or subtracting a
texture, surface, or other details. What is unique about MakeVR is its ability to send 3D models
directly to a 3D printing service. 3D printing is the action or process of making a physical object
from a three-dimensional digital model, typically by laying down many thin layers of a material
in succession. The ability to send 3D models directly to a 3D printing surface is exceptional as
this can allow the designer, carpenters, and the director to be at ease as a 3D printer will be able
to create a meticulous object that would have been time-consuming when constructing it from
scratch.

From these four different circumstances, ranging from experimentation to developed
research, all four groups have concluded that VR enabled them to envision a design that a
traditional scale model wouldn’t have been able to provide. These productions have benefited
from the use of VR and other VR tools. The feedback provided back to these members has been
overwhelmingly positive. VR allowed these designers, directors, carpenters, and other
production members to pinpoint any problems early on, start discussions on the details of a
design, or the construction of a build, and to confirm that everything about the design is correct.
Chapter 3: Solvable Complications of Using Virtual Reality in Scenic Design

Chapter 3: Negative reactions when using VR

Although there seem to be many benefits from the multiple examples presented in the last passage, such as allowing the production team to view the set in a 1:1 scale, pinpointing any problems early on, starting discussions on the details of a design, conversations on the construction of a build, and enhanced visualization of colors, textures, and other details before the set is built, there are many complications and concerns when attempting to incorporate VR into the design process, as VR is relatively new to the theatrical world. However, these complications may seem temporary and fixable as more research and experimentation will resolve some problems that persist when beginning to use VR. Some of the concerns that Huse and Strom found during their exhibition (they received surveys from 56 participants at the 2018 USITT Conference) were nausea, disorientation, fear of heights, and difficulty not exceeding the boundary as there is a limited amount of space set in the VR environment, so users do not get lost or continue walking forever. Huse and Strom reported that nine percent of the 56 participants had nausea, while another eleven percent experienced disorientation. As a result, around five to six people of 56 would experience these symptoms when wearing a VR headset for the first time. Latency and refresh rates on the screen can also cause disorientation when using VR. DamJam, an author on KommandoTech explains latency as, “the time it takes for your actions to be registered in the game. In other words, it is the delay between when you move your head and when you see the corresponding movement in the game” (DamJam). So, if there is a delay on the screen and your corresponding body movement tries to match it, but the timing is off, this can cause disorientation and nausea, similar to motion sickness. When Huse and Strom asked if the
onlookers wanted to experience VR, many observers mentioned that they did not want to participate due to the concern of nausea and disorientation. Huse and Strom also noted that some “Individual participants . . . experienced a fear of heights and difficulty not exceeding the boundary.” (Huse, Strom, 40). One might think working in VR may seem like a void, but that is why there is a boundary to prevent moving too far from the workspace. These negative responses can be resolved by spending more time with the VR technology, more experimentation, and proper body management. Some steps to improve body management and to be more comfortable in VR to resolve the negative responses like disorientation, nausea, and not exceeding the boundary, could be taking frequent breaks, and adjusting your VR headset to your preference. Adjusting your VR headset to have a more pleasant experience may include balancing the weight of your headset or adjusting the lens. Other experimentation and steps to improve your experience in VR is to simply play some basic games or watch movies before learning how to use VR to showcase a design.

Chapter 3: Beginner friendly and Repeatability

Other challenges worth noting by Huse and Strom were that the VR programs had to be easy to learn and use, operate fluidly, and repeatability. Some of these challenges, such as learning and operating the system, can be settled as someone with a firm grasp of the technology and plentiful knowledge, like Huse or Strom, may easily translate the information to another student or colleague. However, a more considerable challenge is if the process and design can be done repeatedly and consistently, quickly, and efficiently. The process of navigating and creating a scenic design model in VR can be done the same way, but it would depend on whether the scenic design may be small or extravagantly large. For smaller sets fitted inside a black box or
in-the-round theater, it would seem that VR may not be necessary unless many moving scenic elements would hinder any production member's vision using traditional methods.

Chapter 3: When to use VR During the Scenic Design Process?

This challenge of consistent processes and designs brings up the next complication in VR replacing traditional design methods. VR cannot entirely replace the whole design process, but it can be incorporated at some point in the design process and can enhance the design. The reason as to why VR is not able to entirely replace the whole design process is because of the early stages of a scenic design explained earlier. As designers begin their scenic design, one will not need VR simply because there is no design to be made yet. As mentioned earlier, research images are what designers are looking for at the start of the scenic design process to solidify on how the scenic designer wants to convey the scene and how they want their set to support the plot. These research images are too abstract and informal to begin creating something in VR. Once scenic elevations and drawings are created, a scenic designer can begin creating a 3D model in VR in place of a scale model. One could decide to use VR in the early stages if they choose to do so. However, it may be time-consuming, unyielding, and unorthodox as no preliminary design has been made to showcase to a director.

Chapter 3: Multi-Participant Viewing in VR

The final challenge, yet benefit, of VR is how VR is used as a presentation device for the entire production and creative teams, especially for the director. Campbell and Wells mention that VR allowed design critics and scholars to visualize the design as it developed while replacing the need for a physical in-scale model and clarifying what was not apparent in CAD drawings. Many individuals may have trouble looking through a model that is only a quarter of
an inch to a foot because of how small each model piece is. There might be problems visualizing if the model may be even half-inch or a full inch to a foot. VR allows and clarifies many questions that may arise with small models as they can become difficult to process on such a small scale. Upon their presentation, Campbell and Wells created taped "walk-throughs" in VR to allow their audience to follow the path Campbell and Wells were leading them on. The walk-throughs allowed the designers and other members to help coherently visualize their intention in the design. Likewise, from the first show that Huse and Strom worked on at Florida State University, *The Servant of Two Masters*, the director was able to see the set in full scale in VR and was able to identify and fully understand the exact size and placement of each object. During production meetings, the director and other production members highlighted specific elements of the sets and how actors could interact with them. Allowing the director and other production members to see the set in full scale makes the design process more fluid as they can walk around the set as if it is already built. With the second show, *Candide*, the scene shop used it to experience the set and discuss construction possibilities. VR replaces the need for physical in-scale models as model pieces can get small and be made without many details, or it may be hard to visualize the space with small objects. As someone who is a carpenter themself, models can be hard to maneuver and visualize if many scenic elements are moving around. The construction process may be more straightforward once everyone understands how the set is supposed to function. Similarly, Peter Frost and Peter Warren from The Interactive Institute/Malmo University College in Sweden were attempting to develop a process to use VR as a tool for designing architecture, specifically the design of a fume hood. The case study carried out was separated into two sections. The first section had workbooks and a design-game participants
interacted with. The workbooks were given to participants, working in pairs or groups of three, to evaluate their work environment and for writing down notes on the positives and negatives about the fume hood in the center of the room. A fume hood is a type of ventilation device that is designed to limit the exposure of hazardous and toxic fumes. However, Frost and Warren noted that the space to view the fume hood became crowded and this became a danger to everyone. Participants in the design game had a set of cartoon pieces in various shapes and sizes used to create different layouts for future labs and workspaces. In the next section, 3D models and VR were used to look at the fume hood again. Participants evaluated the model in greater detail by focusing more on spatial questions like sightlines and dimensions. Frost and Warren concurred those untrained participants can see and understand things that could not be done in the traditional methods. The actual volume of spaces, sightlines, heights, elements overlapping one another, and the immersive scale 1:1 VR environment gave everyone a better understanding of the design.

However, Campbell and Wells raised the concern of some critics, directors, and scholars who commented that "they would have gotten more out of the experience had they been able to walk or fly through the design themselves rather than depend on views from a particular path flown for the presentation" (Campbell, Wells, 6). This means that more VR systems would need to be purchased, more time would be needed to train members on the systems, and presentations and discussions would be awkward with audience members who cannot experience the simulation in three dimensions. Campbell and Wells suggested to introduce an inexpensive, multi-participant VR system to address the problem. By introducing an inexpensive, multi-participant VR system, anyone on the production team who would like to take a walk in a VR set
or follow along the presentation can simply do so by putting on a headset. This can perhaps allow for long-distance meetings for a designer, scenic designer, and other participants as the scenic designer can share their view within the VR headset to the group. Ultimately, VR can be the future of the scenic design process.
Chapter 4: Experimenting in Virtual Reality

Chapter 4: A Negative Past Experience

From past experiences during the early parts of the COVID-19 pandemic, attempting to showcase sketches, elevations, and a scale model to the director was challenging and extremely difficult. First off, everything needed to be transferred into some digital form because everyone had to work from home due to the Covid-19 lockdown. From the physical sketches, elevation drawings, and paintings I had created, I used the camera from my phone to take photos and then upload them onto Box. Box is a cloud storage and sharing platform that allows team members to store files in a location for other members to see if they choose to do so. After uploading my design photos onto Box, I had to explain these drawings, so other collaborators would understand what I was trying to depict. I set up meetings over Zoom with the director to explain in more detail what I wanted to portray, but there was still a bit of difficulty. Zoom is a video conferencing platform that anyone can access through a computer desktop or mobile app. It allows users to connect online for video conference meetings, webinars, and live chat. Sometimes, my room did not have the best lighting, which caused the design works to be a bit blurry, or the director had trouble looking at all the different details on the computer screen. The scale model was the most challenging part of showcasing the design over Zoom. As mentioned earlier on, scale models can be petite. A scale model and a webcam not suited for showcasing small objects are a recipe for disaster. I immediately had trouble adjusting my model to the correct height so it would line up with my laptop webcam. I had to place multiple boxes under
my laptop and my model so I would be comfortable moving model pieces around and seeing my mirrored image on Zoom if everyone else could see the model. Seeing my mirror image is similar to if I was looking at a mirror and holding an object, but I was not able to see what the object was that is on the mirror. This particular set I was designing had many scenes that had many moving parts ranging from chairs, tables, rolling platforms, and other objects. It took a lot of work to keep changing out pieces for each scene while attempting not to knock down any other model pieces. However, with VR technology, showcasing a design through VR can be more fluid and effortless, either with the production team all in one room or with long-distance meetings across the country with the director.

Chapter 4: Viewing Marisol in VR

As mentioned earlier, I took a past production I designed, converted it to VR, and compared it to traditional methods of scenic design. The process I developed was similar to the approach and research Colin Huse, and Jason Strom had done, but with different software. I first used Vectorworks to create my 3D model of Marisol. Then, I took it a step further, importing my 3D Vectorworks model into Blender. Blender is a free and open-source 3D computer graphics software tool that is used by many artists for a variety of entertainment needs such as creating animated films, visual effects, 3D-printed models, motion graphics, virtual reality, and video games. I decided to create two files of the same model because of my limited knowledge of 3D modeling and how limited the details were in the Vectorworks model.
In the Vectorworks model, the details were not up to par with what I wanted to achieve. I was not able to accomplish creating advanced curves in Vectorworks compared to what was physically built by our carpenters. I wanted to use Blender to not only enhance those details, but to remodel some of the 3D scenic elements. Another reason why I decided to use Blender is due to the lighting. Vectorworks has different modes that users can operate such as “designer”, “architecture”, “spotlight” (used for lighting), and many more. However, I was only affluent in designer mode and had no knowledge on how to operate spotlight mode. In Blender, I was able to easily navigate and use shadows more like an actual stage set with lighting. As Blender allowed for more tools in adding detail, I imported my Vectorworks model into Blender so I
wouldn’t need to remodel any of the scenic elements from scratch. I would then add or fix the textures and lighting seen in the *Blender* model.

**Figure 2. A front view of a Marisol 3D model in Blender**

Comparing the *Vectorworks* and *Blender* models, the *Blender* model has lights emitting from the green/blue “glowing wisps”. The middle-curved structure is now a green concrete rather than grey. The brick on the two outer “walls” and the fire hydrant looks more realistic. I was also successful by adding words onto some of the walls in the model. By adding words on the walls, I knew the layout between each word on the walls and how large each letter needed to be by the time I needed to paint them.

Although *Blender* was used to further enhance the details of the set design, it was exceptionally challenging. Compared to *Vectorworks*, *Blender* was difficult in creating 3D
models. When watching tutorial videos on creating a basic 3D model in Blender, each artist would have a method they would prefer making it problematic for me to determining what was best. Navigating through the controls within the software was troublesome as it was completely different than Vectorworks. Vectorworks, although still challenging in its own way, seemed more user-friendly and easier to navigate.

After creating the models in Vectorworks and Blender, I transferred the models to VR. I had to install a new 3D-viewing/VR software that was compatible for my Vectorworks model called Twinmotion. Twinmotion is a real-time 3D immersion software that allows users to view their models in the space in seconds while producing high-quality images, panoramas or 360° VR videos. Twinmotion allows me to look at the model more freely while using the tools it has to create a more dynamic environment or for a better viewing experience. Some of the tools that Twinmotion offered that I found helpful are environmental lighting and pedestrian walking. The various environmental lights that are offered ranges from a narrow spotlight, as if it were shining on a single actor on stage, to a sky light that creates an environment as if it was day time. In Twinmotion, I was also able to change the time of day and the weather, which was helpful in figuring out which scenes were happening at what time of day. The pedestrian walking tool is a unique tool that is one step away from VR. This tool allowed me to act as a pedestrian walking on the same level as the stage simply by using my keyboard and mouse to move and look around. Although these are great tools, there were some other aspects that I either found confusing or irritating due to my lack of knowledge and experience when working with this new software. I was not able to change the entire environment and was stuck with a pre-loaded cityscape in the background. I only saw this background if I was on stage looking towards the
another annoyance was that some of my textures and even some scenic elements from my imported Vectorworks model were lost. I surmised that the reason for this, although not tested, was that Twinmotion did not detect the original texture from Vectorworks because it was a pre-saved texture. Other textures I used from the internet worked fine. The scenic elements that disappeared could be another detection problem from Twinmotion as it did not recognize the 3D scenic elements as actual 3D objects. Overall, there were some great tools provided by Twinmotion, but with some more time and experience using Twinmotion, I would be able to find the root of the problems and restore the model to what it would have looked like in Vectorworks.

I did not need to download any new software to view my Blender model in VR as Blender has its own VR viewing system imbedded in the software. It was frustrating to connect my VR headset, the Oculus Quest 2, to my laptop and view my 3D models in software. After researching and testing for a few days, I found I needed an Oculus Link cable. An Oculus link cable is a long physical cable, 5 meters, specifically for the Oculus Quest 2 in order to have my laptop connect to the VR headset. I also needed to download a new software onto my VR headset called Virtual Desktop. This Virtual Desktop app is designed to have whatever is shown on my laptop screen be shown through the VR headset. For instance, if I had Blender running on my laptop, everything is paired correctly and Virtual Desktop is running on my VR headset, then I would also see Blender through my VR headset and be able to interact with it. After these few days of researching, testing, and finally pairing everything correctly I was able to view my 3D models both in Twinmotion and Blender. My first impression of looking at my models in VR was jaw-droppingly enthusiastic. I was blown away by how everything was in a one-to-one scale as if
our carpenters had just built the set and loaded it in. I was able to “walk” around the space, look at the textures up close, and “walked” through each doorway/entrance/exit. In VR, there are two boundaries that need to be set before using a VR headset, a controlled or a stationary boundary. These boundaries are to protect the user from going past a set boundary, so they do not bump into anything and injure themselves. A controlled boundary is a boundary where a user can draw out a specific area that they are free to move around in it a few feet in their living room to something larger like an entire theater stage. However, when “walking” around spaces in VR, I was in a stationary boundary and only able to move a couple of steps. *Twinmotion* and *Blender* have their unique way of “walking” in spaces within VR if a user is stuck in a stationary boundary. In *Twinmotion*, “walking” is by teleporting and physically walking. With the VR hand-held controller in either hand, there is a circled arrow that will allow a user to point and click at a spot they wish to be at. At that spot the user may physically walk around depending on their boundaries and continue teleporting if they need to. In *Blender*, there are more methods to move around besides physically walking. *Blender* has three different ways to move, all using the VR hand-held controllers. The first way, like *Twinmotion*, is to teleport with the same point and click. The second method is dragging yourself as if there were many invisible ropes on stage. The final way which is the easiest of the three is using the joysticks on the controllers. The joysticks are multi-directional which means whichever way your joystick points you to, that is the direction you will be going, so a user can move forwards, sideways, backwards, and even go higher or lower. After spending some time in my room viewing both models in VR and familiarizing myself with the new software and controls, I decided to showcase what I had done to a small audience. As I was testing my software and VR headset at school, I noticed there was
a slight change in quality. This change in quality was due to the internet speed, how many people are using the internet at the time, and latency. When testing a day earlier in the week when school was busier, I noticed a lot of lag and freezing on my VR headset. Lag is the delay between what the user does, and the reaction speed is of the software. For instance, in VR, if I walk a couple of steps forward, but the VR headset does not do the action of walking forward until seconds later, that is lag. Freezing is when whatever is seen on your screen gets stuck for a while. However, when using my software and VR headset on a less busy day, I noticed the lag and freezing were gone and the quality was similar to what I experienced at home.

The audience for my showcase were thrilled and had positive remarks on the presentation of viewing a scenic design model in VR. Some audience members decided to participate and used the VR headset to view the model in VR. These same members mentioned that this was their first time using a VR headset. The participants gave positive remarks on the effect it would have on scenic design presentations, gaining knowledge of what the scenic design will look like in a one-to-one scale, and the ability to make decisions on whether scenic elements need to be moved, sized down, or even altered before being built. Some participants also provided feedback by asking for clarification on some key terms of visual support like what a boundary box is or suggesting to provide multiple graphics on the controls as explaining them verbally may have caused confusion since they were unable to look at the controls while wearing the VR headset. Thus, after some research and experimentation, I conclude that using VR is superior in showcasing a scenic design model compared to traditional methods of using a physical scale model. Although using VR may be challenging in the beginning, the time and effort poured into learning the software as I did will benefit everyone in the future allowing for the creative and
production team to resolve any conflicts before building any scenic elements. VR is an effectual tool that can be integrated into the scenic design process while serving as a more refined alternative to showcasing a scenic design by traditional methods.
Chapter 5: Closing Remarks

With VR on the rise and beginning to make its way into the theatre world of design, many new productions have begun to use VR to enhance their design or to view a design before it is built and put onstage. However, VR cannot simply remove the traditional methods of design. Initial research, storyboards, and sketches may be done without the need for VR, but once an idea is set and designers can construct a model to put into VR, this method may benefit everyone on the production team. VR has many benefits already, yet it also has many complications. However, as discussed earlier, many of these complications are solvable with some time, practice, experimentation, and further research. Thus, with time and experimentation, virtual reality can be incorporated into the scenic design process, but also be a better alternative to traditional methods when presenting a design to the production team.


