Development of the Jazz History Database Virtual Museum

A Major Qualifying Project Submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree in Bachelor of Science in Interactive Media And Game Development

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Weiss JAZZ HISTORY DATABASE

Abstract

The Jazz History Database Virtual Museum is a virtual reality (VR) museum experience featuring content from the Jazz History Database (JHDB). The primary goal of this project is to create a space to welcome those who might otherwise feel that the world of jazz is arduous to enter or intimidating, help record the history of jazz, and encourage curiosity to explore and experience the world of jazz interactively.

The Jazz History Database Virtual Museum was developed using Unreal Engine 5 for the HTC VIVE VR headset and Oculus Quest; it is available for Windows.

We completed this Major Qualifying Project (MQP) as part of the Interactive Media and Game Development program.

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1 Introduction

A virtual reality (VR) simulation often uses 3D near-eye displays to offer users a realistic, immersive reality experience. The goal of this kind of VR is for the user to feel entirely immersed in the simulated reality. VR does this by using numerous projection technologies and/or head-mounted displays. Various fields have used virtual reality technology, like entertainment (movies, video games, et cetera), education (medical, military, et cetera), and business (meetings). (Bos et al., 2022)

"Presence" is the feeling of "being there" in virtual reality (VR), and it is essential for creating immersive experiences. There is agreement on three standard features of presence as an essential component of VR experience: (1) presence requires involvement in the virtual environment; thus, the effectiveness of VR is associated with the sense of presence reported by users; (2) presence is defined as a subjective experience; and (3) presence is a multidimensional construct. (Berkman and Akan, 2019) If excellent sound design is combined with careful interaction and virtual environment implementations, VR users will feel an increased sense of presence in the simulated world. The sounds in VR systems must match the spatial qualities of the shown environment for complete immersion. For example, if a vehicle is moving away from users in the VR world, the users should hear the vehicle's sound getting quieter, more reverb on the sound, and maybe even a decrease in pitch. The immersion of virtual reality is instantly gone if the sound is not designed well.

Furthermore, in jazz, the essential task for consumers is listening. We wanted to use sounds to lead viewers imperceptibly and unconsciously to gaze in a particular direction of the virtual world that fully envelops them. Using a compelling and immersive sound experience to tell a story and evoke emotion is complicated in a VR environment. Sound has the capability to express a wide variety of emotions that would not be possible without it. For example, a moment of silence could mean many things, and a single footstep can produce longingness or fear.

We developed this project over the 2022-2023 academic year at WPI. The development work included design, technical, artistic, and audio aspects. On the artistic side of the experience, we chose and developed the concept for the museum and two different environments. On the technical side, we created a VR controller system in Unreal Engine 5 with movement tracking, continuous locomotion, teleportation, and object interaction. We also implemented an inspector mode for non-VR users (detailed in Section 5.6.2).

The report has nine chapters: Introduction, Background, Design, Artistic Implementation, Technical Implementation, Audio Implementation, User Testing & Analysis, Conclusion, and Future Development.

The first chapter – Introduction – contains a brief description of the project and the report's content.

Next, the Background chapter focuses on the target audience, the inspiration for this year's design and gameplay of the virtual museum, background research on jazz, and previous project implementation. This chapter also discusses the mission of our sponsor and their input for this year's project. We also discuss the decision on the engine used for this project.

The Artistic Implementation chapter discusses the art assets for this project's documentation and environment design. This chapter focuses on placement and environment design.

The Technical Implementation chapter discusses the important programming and blueprints present in the Unreal Engine project and their functions.

The Audio Implementation chapter explains the usage of sound in the project. We describe what sounds are used, where they are used, and how those sounds are activated.

The User Testing & Analysis chapter records the methodology for collecting user experience inputs and how we interpreted that data to inform our decisions and the recommendations for future groups.

The Future Development chapter provides documentation that may be useful to future groups working on this project. It also contains recommendations for features to add or test that we did not get to implement and test properly.

2 Background

2.1 Jazz History Database

The Jazz History Database (JHDB) is a non-profit organization at Worcester Polytechnic Institute that archives recordings, interviews, photographs, and other jazz artifacts from around the world that might otherwise disappear over time. For every big name in jazz, dozens of talented artists do not make it to the national scene. The goal of JHDB is to celebrate the accomplishments of these artists, whether in music, poetry, visual art, or any other field. Decades of work have gone into preserving countless jazz artifacts since the JHDB was founded in 1999. This archive is publicly accessible via the JHDB website (https://www.jazzhistorydatabase.com/index.php).

In 2020, a team of student WPI successfully attempted to make the JHDB more accessible to a broader population. This team created a web-based tool for developers and remote responders to upload media and storage resources into a simple web form. This was determined essential due to the COVID-19 pandemic occurring at the time. The tool created a new realm of accessibility for the JHDB audiences to approach the content remotely and reduce the chance of exposure to the virus (Matticoli and Varella, 2020).

Continuing collaboration between the JHDB and WPI, during the 2021-2022 academic year a new team worked with the JHDB for their Major Qualifying Project to further modernize the museum. They wanted to create an environment in virtual reality to provide a more engaging interactive experience. They believed that a VR environment would be a "new and effective way to preserve and showcase some of the JHDB's resources" (Fish and Higgins, 2022).

Our project is a continuation of the 2021-2022 JHDB Virtual Museum MQP. We expanded this VR application with the goal of bringing in new jazz audiences through a modern platform. We hope that by using this approach, we can create a new point of view into the world of jazz to make entering that world less intimidating and more fun for those with little experience.

2.2 2021-2022 JHDB Virtual Museum

The 2021-2022 JHDB Virtual Museum Major Qualifying Project (MQP) was a collaboration between the JHDB and the Interactive Media and Game Development Program that set out to build an interactive 3D environment for virtual reality. This collaboration attempted to find a new way to preserve resources about jazz and make them more approachable to modern audiences. The 2021-2022 project team, Nicholas Fish and Annie Higgins, created a virtual environment for the JHDB with significant artistic assets and musical recordings.

The environment they created was excellent aesthetically. The detailed textures and environment layout contributed greatly to the feel of a speakeasy, and we wanted to maintain that feel. However, there are some areas that we wanted to improve. First, there was not much interaction or information from the JHDB in last year's project. The only major source of information and interaction inside the museum was grabbing and playing vinyl records. We wanted to include more interaction and artifacts from the JHDB. Additionally, the space was quite small, with little space to move around in. We wanted to create a larger environment that the user could explore.

2.3 Jazz Inspirations

Jazz originated from a merging of African and American styles in the late 19th and early 20th centuries. In the late 19th century, a style of music now known as the blues started being performed on the streets by African Americans. This genre of music likely originated from African American work songs but was altered to be performed by a solo singer and guitar. Like the earlier African American work songs, the blues contained notes outside the standard scale, known as "blue notes." While the blues was gaining popularity among African Americans, ragtime was popular among white Americans. This genre of music was primarily played on piano. At the time, upright pianos were becoming a more common sight in small venues, and for African Americans, the upright piano symbolized a level of wealth they aspired to.

One of the lucky African Americans able to play piano at the time was Jelly Roll Morton, the self-proclaimed inventor of jazz. Morton began his career at 14 playing ragtime. As ragtime evolved, it began incorporating blues elements and additional instruments, particularly brass. This evolution

of ragtime became known as jazz, and Morton's "Jelly Roll Blues" is commonly thought to be the earliest example of jazz sheet music (Hall, 2017).

While jazz is tough to define - even more so than many other genres – it is typically recognized by its mixture of composed and improvised parts, deviations from traditional harmonies and pitches, and the timbres, phrasings, and embellishments unique to jazz performers. Early jazz style mostly evolved in New Orleans, starting in the early 1910s, as described earlier. At this time, black musicians were developing this genre using the instruments available to them, primarily cornet, clarinet, trombone, tuba or bass, piano, banjo, and drums.

During the 1920s and 30s, orchestral jazz became more popular, adding more instruments. This is when Duke Ellington's experimentation began, creating pieces with increasingly complex harmonies and increasingly unique timbres. By the 1930s, swing music was all the rage, with Count Basie's band among the most important. In the late 30s, small jazz combos started becoming popular again. Unlike the small combos in the 1910s, these combos kept the focus on soloists found in the orchestral bands. In the 40s, these small groups were learning from Ellington's complex harmonies, expanding upon them alongside increasing rhythmic complexity, providing new challenges and avenues of expression for soloists. All of this change has occurred in the span of only about 30 years, and this is only a snippet of jazz's evolution.

From here, more offshoots of jazz keep appearing in genres like bebop, cool jazz, chamber jazz, and free jazz. The history of jazz is nonlinear and still occurring today (Schuller, 2023). Of course, a telling of jazz's history would be incomplete without mention of the racial discrimination at the time. While jazz was popular among people of multiple races and cultures in the United States, widespread discrimination for much of the 1900s severely limited the spread of blues and jazz music performed by African Americans. The white-dominated recording industry would not allow recordings of African American performers to be distributed to white audiences, but many white performers could not faithfully recreate the music of African American composers. What's worse is that many white performers performed in shows making fun of black caricatures, and thus were not acceptable by African American composers. However, there were some white artists that worked with African American composers to further the influence of these composers. Marion Harris and Roger Graham were two notable white singers that worked with black composers. In addition, many Jewish Americans sympathized with the plight of African American artists, and thus did work to popularize jazz as well. Some notable figures are: Belle Baker, a Jewish blues singer; Maurice Abrahams, a composer that worked with Henry Creamer; and Al Jolson, a jazz and blues minstrel performer who always ensured that the African American actors he was working with got paid equally (Hall, 2017).

The history of jazz is quite convoluted, nonlinear, and multifaceted. There are many important figures, each with their own unique contributions. Additionally, there are many different styles of jazz with their own unique idioms and identifying qualities. The primary goal of the JHDB Virtual Museum is to condense this complex history into a digestible and engaging experience. To accomplish this, we started from the basics: What instruments are standard in jazz, and what information does the JHDB have that we can expand upon? We wanted users to come away with an understanding of the basics of a jazz ensemble and an interest in something they saw in the museum. So, we did not necessarily need to include detailed information; instead, we included various instruments, posters, and interviews. These are little snippets of information alluding to important figures or times in jazz history. We wanted to draw users' attention and pique their curiosity, allowing them to enter the world of jazz history wherever they feel most comfortable. Much like jazz history, the discovery of jazz history does not have to be linear.

2.4   Experience Inspirations

Our sponsor, Ben Young, believes that the most important task in jazz is listening. With that in mind, we wanted to create a space where the act of listening is the main focus. As the great Miles Davis said: "It's just sound. One sound leads to another." (Cook, 2012).

2.4.1   VR Inspiration

Paradiddle VR is one of the best combinations of music and VR. It is a virtual game where players can set up drum sets and play. This game allows users to interact at their own paces and try out a separate set of instruments to create sounds. We want to implement similar aspects to this experience
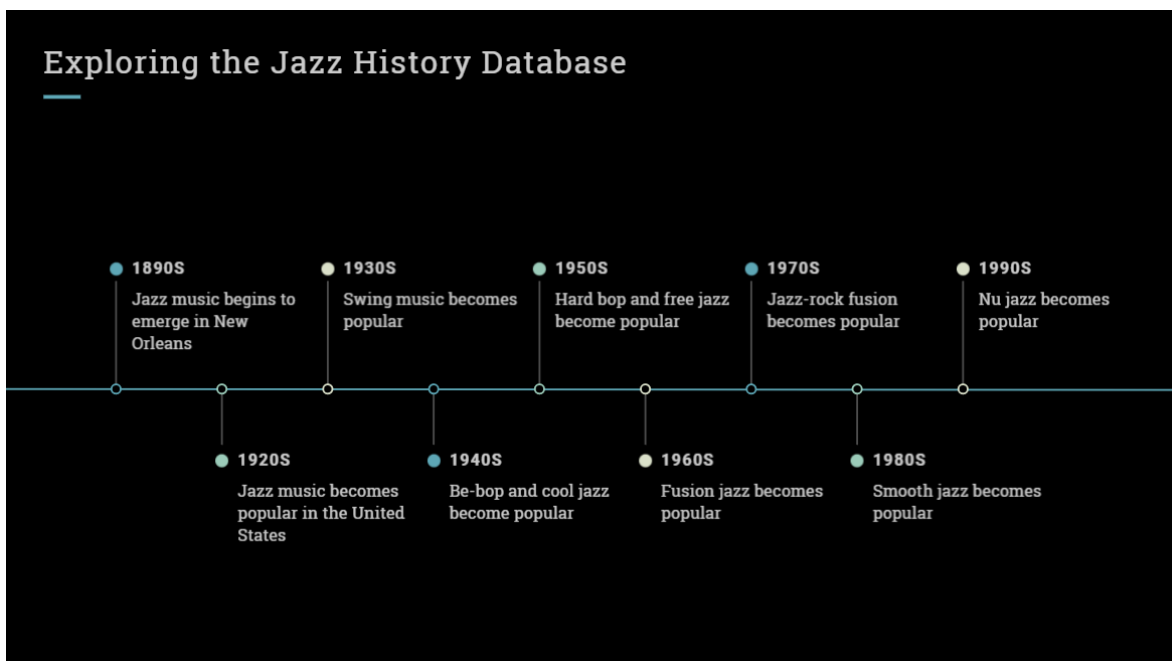
Figure 1: Jazz history timeline (information from the JHDB)

Figure 2: Paradiddle VR Gameplay (Tanirgan, 2018)

Figure 3: Screenshot of The Opening of the Diet 1863 by Alexander II VR Experience

in our design, where users can interact with jazz related instruments and explore the origins of the typical jazz ensemble.

2.4.2 Museum Inspiration

We also took inspiration from real-life museums. Several museums celebrate and preserve the history and culture of jazz music in the United States. Some of them are:

- The American Jazz Museum in Kansas City, Missouri. This museum showcases the contributions of jazz legends such as Charlie Parker, Duke Ellington, Louis Armstrong, and Ella Fitzgerald. The museum also features interactive exhibits, educational programs, and live performances.

- The New Orleans Jazz Museum in Louisiana. Located in New Orleans, the birthplace of jazz, this museum explores the origins and evolution of jazz music. They display instruments, photographs, manuscripts, and jazz musicians' recordings. Additionally, they host concerts, lectures, and festivals.

- Some local museums in Worcester were also referenced in the process of designing this project, including the Worcester Historical Museum and Worcester Art Museum.

2.5 Virtual Reality and Museums

Jazz music has been a source of inspiration for many artists and musicians alike. It has been the topic for many art exhibitions and museums worldwide, including virtual reality (VR) museums. VR technology allows visitors to experience jazz music in a new and immersive way by creating an environment that transports them to a different time and place. For example, the Smithsonian American Art Museum has created a virtual museum called "Beyond the Walls" that presents a selection of unique paintings, sculptures, and multimedia artworks for visitors to engage with as they explore the museum's east wing from inside VR headsets (Smithsonian American Art Museum, n.d.). Similarly, The National Museum of Finland in Helsinki opened a new VR exhibit in 2018 that allows visitors to step inside R.W. Ekman's painting "The Opening of the Diet 1863 by Alexander II" and feel like they are part of the painting (The National Museum of Finland, n.d.).

VR can be used for museum purposes for several reasons. One reason is to enhance visitors' experiences by allowing them to explore the exhibits in a more immersive and engaging way. For

Figure 4: A restaurant layout with a stage (Jazz Club Étoile, 2023)

example, VR can transport users to different places and times, such as outer space, and let them see and touch objects they could not in real life. In the case of JHDB, it is also about digital preservation. Many jazz artifacts dated back to the 1900s are harder to view and access now. Using VR, we can replicate these objects and present them to users without damaging the real ones while still allowing users to interact with them. Another reason for VR in the museum is to increase the accessibility and reach of the collections by making them available online or in other locations. The JHDB does not have a physical location for audiences. However, they have an online domain where the experience can be hosted so that people who cannot physically visit the museum can enjoy the exhibit from their homes, work, or school. Lastly, a VR space for the JHDB can create new forms of artistic expression and storytelling using VR. For example, the JHDB can host a meeting in the VR space and create an interactive and immersive narrative that tells the story of the museum's assets in a novel way. Using a VR environment can also encourage creativity and let visitors who could use museum resources to produce content. The JHDB can profit from using VR to market its content and draw in younger people.

2.6 Artistic Inspiration

During the project's first phase, we were intrigued by how the general public came across jazz. We started by considering scenarios in which people would be exposed to jazz. People may come across jazz unintentionally in different ways, such as hearing jazz through movies, TV shows, and commercials, encountering jazz dance through Broadway musicals and street performances, or learning about jazz history and culture in school. Our advisors and sponsors mentioned El Morocco in Worcester as an example of the cabaret scene as a gateway to jazz. El Morocco was a hot spot for jazz during 1943. We believed that an environment like this could encourage active listening, which was not explored as much in last year's MQP. Our idea is to replicate the lively and upbeat atmosphere at El Morocco without necessarily copying the venue directly.

We were also inspired by the design of some real-life museums. Some historical museums, for example the Worcester Historical Museum, have different rooms to replicate the architecture of different times. Using this approach, we could recreate an era of jazz in a virtual environment to convey information about jazz in that era and tell the stories of important individuals from that era.

2.7 Software Choice

As this project continues the previous year's project, Unreal Engine 5 (UE5) was used in the development. The main reason for using Unreal Engine 5 is the control that this engine version gives developers over the game's scope, look, feel, and mechanics. Unreal Engine 5 provides excellent visuals, audio, and physics for VR production. In particular, Nanite and Lumen were two technologies

that significantly improved the visual quality of the museum without much processing overhead. One benefit that UE5 provides developers with is that applications can be developed using both C++ code and Blueprints, which is Unreal's visual scripting language. This gives us more flexibility and control over the logic and testing. Unreal Editor also helps us test the VR apps in real time while developing. Additionally, it provided a rich set of resources and support for VR development, which we can use to find high-quality assets and get help from other developers. As Unreal Engine 5 was officially released on April 5, 2022, more studios are using it, creating more development opportunities like collaborations and low-cost, high-quality assets (Epic Games, n.d.).

2.8 Hardware Choice

For hardware, we chose to use the HTC Vive headset and the Meta Quest to develop our project.

The HTC Vive uses external tracking stations to track its position in a room, making its tracking very accurate. It also has a wide field of view and a high resolution with low latency. The Vive is compatible with SteamVR, which allows for easy testing in Unreal Engine 5. This headset also has different models and accessories that meet different budgets. Users who want more immersive interaction can use accessories to enhance their VR experience.

The Meta Quest is a wireless all-in-one VR device, which makes it more convenient, portable, and accessible for us when playtesting and for users. Moreover, Unreal Engine 5 supports the Meta Quest, allowing us to test and distribute the application on this headset. The Meta Quest has a large user base and market share due to its parent company, Meta, being a massive technology company. By developing for Meta Quest, we can make our museum reach a broader range of audiences.

3 Design Considerations

3.1 Experience Goals

We aimed to establish a space somewhere between a jazz club and a museum. We wanted the space to integrate jazz elements and invite users to discover and familiarize themselves with various jazz-related media. At the same time, we also wanted it to provide a new experience for jazz enthusiasts. Since this is a museum experience rather than a game, we wanted it to be as easy to control and navigate as possible, even for a beginner with no VR experience. Furthermore, we wanted to create a unique active listening experience and emphasize the instrumental aspects of jazz.

3.2 Target Audience

We wanted to create an experience for people curious about jazz and offer a virtual space for those who are already familiar with it but want to experience it in a new way. The target audience in the U.S. primarily appeals to adults aged 35+ (De Novo Agency, 2023). As a result, many people unfortunately associate the image of jazz with the older generation and traditional values. Moreover, jazz is often described as complex and sophisticated and often appears in high-end places with age restrictions (MasterClass, 2021; Schuller, 2023). These facts can make jazz seem challenging to the younger generation. The primary audience for jazz music may be the older generation, but this does not imply that younger groups are indifferent to it. This museum aims to cater to both mature and younger audiences and to provide them both with an opportunity to appreciate and enjoy jazz.

In our conversation with Ben Young, our sponsor, we discussed the target audiences of jazz and the virtual museum. He identified that he wanted the project to appeal to people who want a jazz experience first. He also wants to attract a general population into the VR experience that can be influenced to enter the jazz world.

3.3 Scope

This project is an immersive experience rather than a game. A game is an interactive activity that involves one or more players following rules and objectives to achieve a goal or to win a prize (Bond, 2018). In contrast, our project does not have any explicit rules but instead focuses on creating or achieving a certain mood or impression for the user. While these factors can be mutually exclusive,

games and experiences may have overlaps or exceptions. We wanted to provide structure to the audience so that they would not be lost in the environment without falling into more game-centric elements. To achieve this, we implemented interactive elements for users to interact with while trying to simulate a real-world situation. Instead of explicit goals, players can investigate the environment in their own way, whether to have fun or learn. This way, the users can enjoy the experience at their own pace.

Because VR is both a complex environment and a complex interface, we do not want to overwhelm users. We must create an environment where the user is guided and not overwhelmed with too many choices and information. Not everyone is familiar with VR technology since it is still fairly expensive and difficult to set up for most. Secondly, in user experience, the standard rule is that developers cannot assume their user's knowledge on any subject (Lee, 2023). In this situation, we cannot assume users know what to do in a VR experience, where to go, and how to move. So, designing an experience involving slow and progressive familiarization, with visual clues and simple guidance from the software, should be able to assist a much broader range of users. When creating a VR experience, it is essential to consider both the system's and users' powers. Therefore, developers must comprehend their customers and any potential problems arising as they use VR.

Since this is an experience, there is no end condition. A good user experience here gives users the option to stop the experience and return whenever they want to. This museum experience is also tailored to this option. The space, design, and interactivity are not only about letting the user quit when they wish - they are also specifically designed and oriented for that. The goal is to create an enjoyable experience in shorter sessions that can be resumed later.

4 Artistic Implementation

This section describes the artistic implementation and the tools used to develop the Jazz History Database Virtual Museum. During the first term of this project, we lost our dedicated artist due to unforeseen circumstances. Because we did not have a dedicated artist on the team, this section will only discuss the asset pipelines for the environment and the reasoning behind them. Most of the models used in the project are free-to-download packages from Unreal Engine Marketplace, while team members make some to complete the feel of the environment.

4.1 Conceptualization

The environment and prop production pipeline began with looking into last year's project and gathering reference images for the type of space the team wanted to create. Last year's project implemented a speak-easy space where the users can listen to music by changing the records on the shelf.

Multiple ideas were collected and discussed among team members on which ideas to move on. During the first stage, none of the ideas were finalized and were all put into the draft box. Nevertheless, we all agreed that the space must include a stage where users can interact with instruments and see the band layout. Having a stage with musical instruments serves the purpose of showcasing live music performances by jazz artists and bands as well as the instruments themselves. The second reason is to provide a platform for musicians or non-musicians to learn about music and express themselves. Jazz has historically been played on stages in clubs. We tried to honor this history using the stage layout.

Furthermore, having a stage in the environment also drew users' attention to the main area and served as the focal point of the environment. We wanted to use instruments to create a particular ambiance or mood for the restaurant. For example, when a user sees the trumpet, the instrument often associated with festive occasions, they can immediately link the surrounding with fanfare or celebration because of its bright and powerful sound. These reasons led to our main focus for the first implementation of the project, a gray box space where instruments are displayed for users to interact.

This idea is translated into Unreal Engine 5 with some basic models from the Engine and the Twinmotion Musical Pack 1 for the musical instrument models from Epic Content.

We experimented with a few layouts and selected the one in Figure 5 for the museum's first iteration at Alphafest. The reason was that the placement of each instrument in this layout was made to replicate the actual layout of the Jazz Big Band. This layout was designed to maximize the result of recording for big band jazz and for a packed room audience to have a better listening experience (Rogers, 2020).
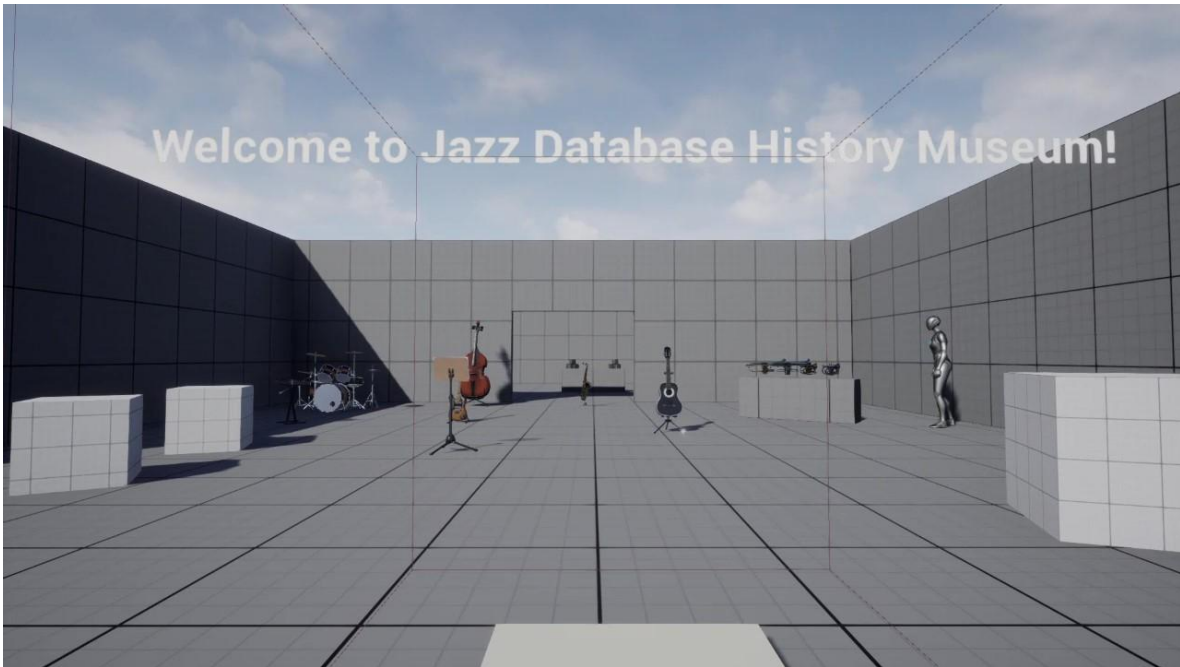
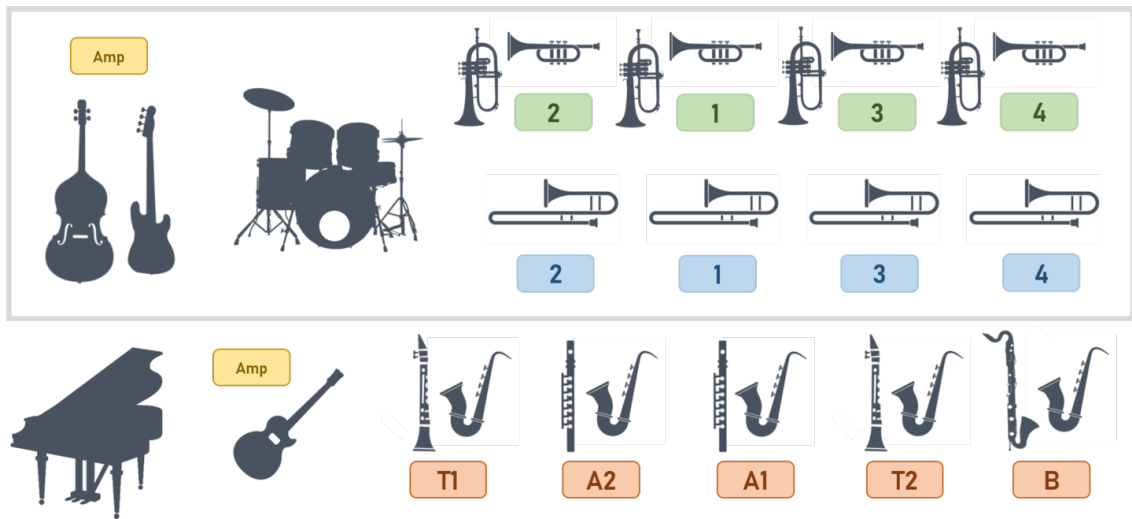Figure 5: First iteration of the Jazz History Database

Figure 6: A typical big band layout (Rogers, 2020)

Figure 7: Second iteration of the JHDB Virtual Museum

With this layout, we have two options: an orchestra or a small, closed room space as a viable layout for jazz. We recreated a small, closed environment - a cabaret with a stage for a jazz performance. As stated in Artistic Inspiration, we were curious about how people came across jazz daily. By using this idea, we can make jazz seem less intimidating and provide a situation that would mimic real-life exposure to jazz. This idea also allowed us to recreate some historical context of jazz. With this idea in mind, we created the project's second implementation, as shown in Figure 7.

However, during the final stage of the second implementation, we recognized that the environment seemed cramped at that time. The liveliness of a jazz club was not translated in the second iteration, and at the same time, none of the aspects in there could tell the story of jazz or present a contemporary museum aesthetic. So, we decided to redo the space so that it could express our goal more efficiently.

Our goal for the final iteration was to maintain the stage as the focal point and expand the environment to create more room for interaction and display the JHDB content. At the same time, we wanted to achieve a jazz club's lively atmosphere and the museum's educational value; this led to our decision to have two separate environments for users to explore. We believed that having two different designs of the museum can first differentiate the purpose of the space while also making sure that what we intended to stand out and highlight actually stands out in the environment. So, in our first environment, users can interact with interviews and view the facts of an artifact similar to a museum. In the second environment, we focus more on the sound of jazz and the liveliness, the lighting, and the atmosphere of a jazz club. Another reason for having two different designs is to allow our users to accommodate different populations' needs and tastes. This does not change the core functionality or the project's goals but gives users space to explore more and be creative. Lastly, we also believe that having two separate spaces could be cultural adaptations that represent what the jazz history database is willing to modify to suit the current market norm and respect jazz's cultural value.

The general layout remained similar for both environments. However, the choice of assets might be slightly different as the first environment represents a contemporary museum while the second one is a speak-easy jazz's club atmosphere.

4.2   Props

Numerous models were added to each display to differentiate between them and to get the desired feel for both environments. Due to our team not having an artist, many of these props were free assets from the Unreal Marketplace, as mentioned earlier. The props we used usually mimicked props in a real museum or in a real jazz club. This is to make the space feel more like a space that would be found in the real world rather than something unique to VR. If we were to include too much functionality
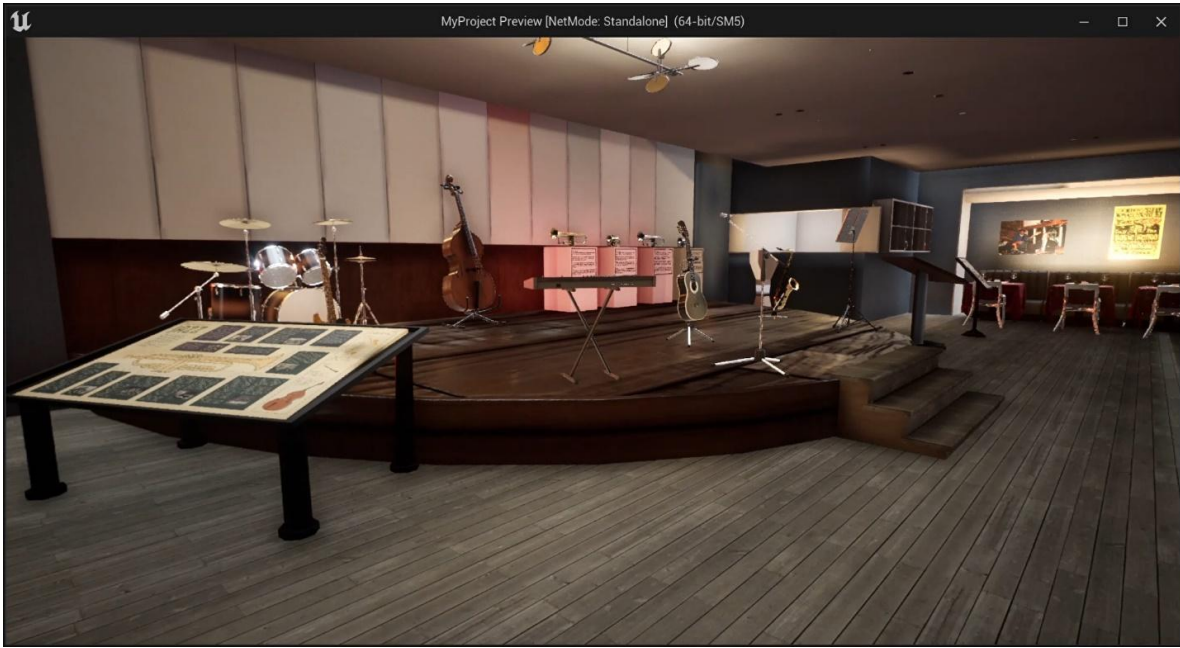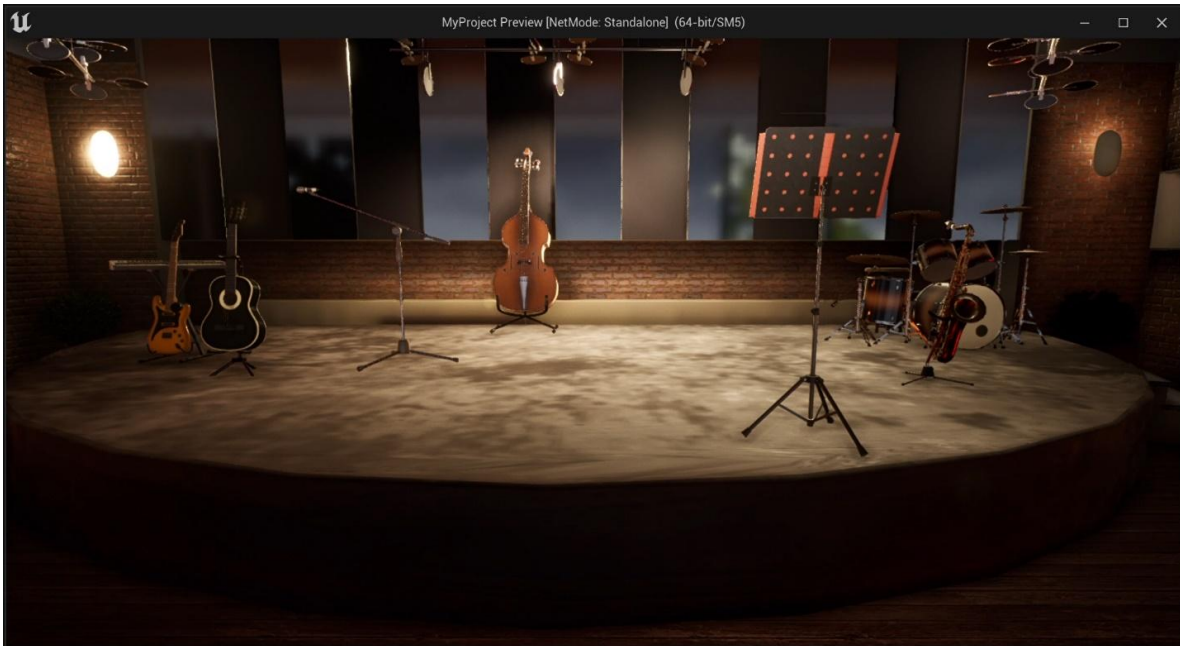
Figure 8: Main stage of the first scene

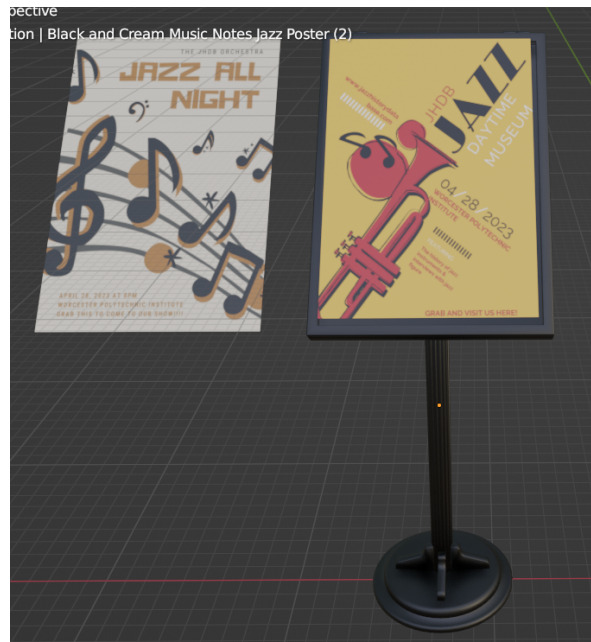Figure 9: Main stage of the second scene

Figure 10: Museum poster stand

unique to VR, it may turn away people who are not as comfortable with VR. Thus, we aimed for a space that is more realistic to make more people comfortable being in that space rather than confused and overwhelmed by a bunch of new and unfamiliar stimuli.

For the first environment, a contemporary museum, the props need to add to the feel of modernness, spark curiosity, and help visitors learn about the past in a fun and interactive way. We used exhibit props to fill up the space and enhance the visitor's experience by recreating a scene or an event, putting up an object in its environment, or showing how to utilize it. With exhibit props, we can provide additional context for educational purposes, for example, to tell the history of jazz instruments.

We also decided to keep the dinner club setting and objects in the first scene. The layout of the Kugelbahn Bars in Berlin inspired this decision. From as early as 1916, art bars and restaurants have been showing pieces of art in their dining section for patrons. By following this design, we wanted to make our museum seem less formal and create a space for enjoyment and learning. The tables and chairs also give visitors a feeling that this space is for viewing and resting.

The second space consists of mostly fine dining-related objects as we targeted to achieve a jazz club look. Even though the stage is the main focus of both spaces, in the second space, the stage was extended to allow visitors to view and hear the performance better.

Dinner tables and chairs were used to give the visitors a spacious feeling for dining and listening to music inside the environment. Additionally, the space contains sofas and armchairs that are plush and inviting for lounging and socializing. These were arranged in groups or along the walls, creating cozy corners or booths while keeping the main stage the focal point. Soft and dim candles and lights were used to light the table area while setting the mood but did not draw attention away from the stage.

4.3 Material

To make our experience realistic in Unreal Engine, applying appropriate materials for props and surroundings is crucial.

The two exhibit spaces in the virtual museum have different color palettes and design styles to create distinct atmospheres for the visitors. The first space uses a bright beige palette to achieve a contemporary look that is natural, neutral, warm, and inviting. Beige can also work well with an elegant design, creating an inviting and simple look.

The two exhibit spaces in the virtual museum have different color palettes and design styles to create distinct atmospheres for the visitors. The first space uses a bright beige palette to achieve a contemporary look that is natural, neutral, warm, and inviting. Beige can also work well with an
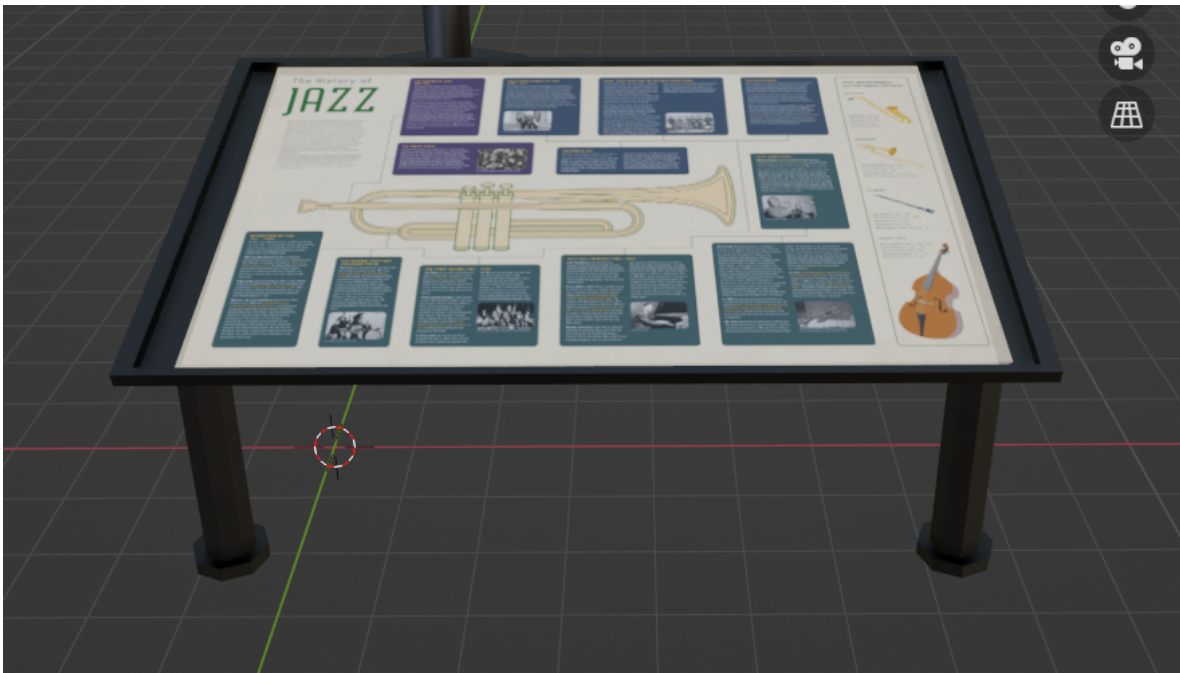
Figure 11: Museum facts stand
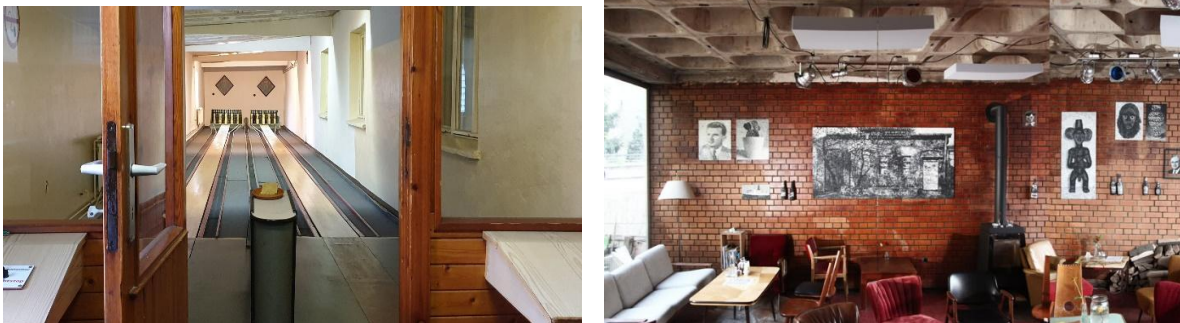
Figure 12: Kugelbahn Bar with bowling alley

Figure 13: Some of the dinner props in the second scene
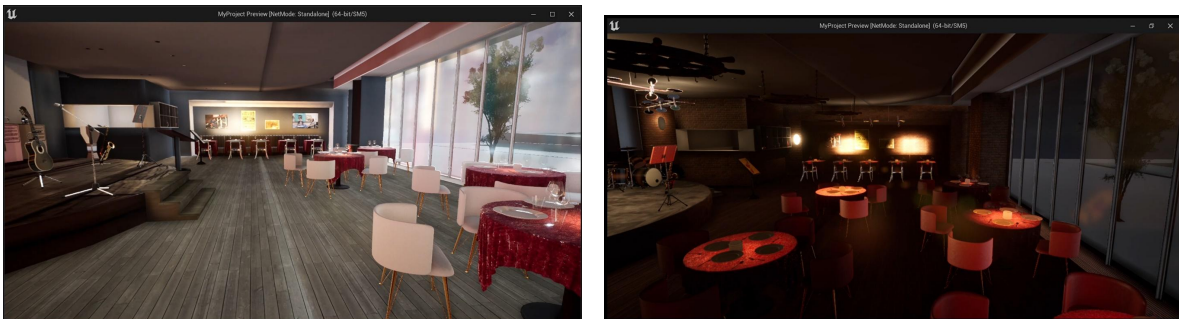
Figure 14: Comparison between the two spaces

elegant design, creating an inviting and simple look (Sullivan, 2022). Going for a contemporary style can also be flexible and adaptable for future implementation, as it can change with the times and incorporate elements from other styles. The second space, on the other hand, uses warm and red brick tone hues to create a cozy and welcoming atmosphere (Benjamin Moore & Co., 2020). The second space aims to appear as a haven for those who want to listen to music and chill or take it slow after a long day. Because of this, it uses a warm brick or red wine color palette for texturing the furniture and other elements, employing a variety of reds, yellows, and browns. Wood materials are also utilized to create a rustic yet fancy look to the space. Both spaces use warm colors but with different shades and effects. The first space is more modern and minimalist, while the second is more traditional and cozy.

4.4 Lighting and Post-Processing

The penultimate stage is to complete the set by adding environment lighting and post-processing in Unreal Engine 5 to give scene 1 a contemporary look and scene 2 a jazz club aesthetic. Because we use Unreal Engine 5, the lighting used the Lumen Global Lighting System. Lumen is Unreal Engine 5's fully dynamic global illumination and reflections system. It offers realistic lighting and reflections, even in extensive and detailed environments, which is highly beneficial for an environment like our project – a highly detailed room.

We wanted a modern dine-in music establishment to look at and a gallery to display Jazz History for the first environment. The team used SkyLight with HDRI to mimic the sun's reflection into the
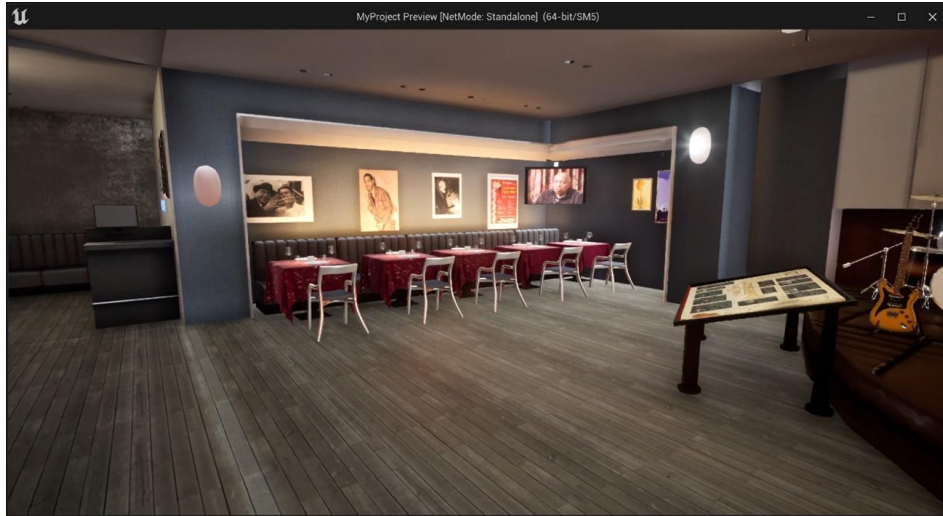
Figure 15: View of the modern scene
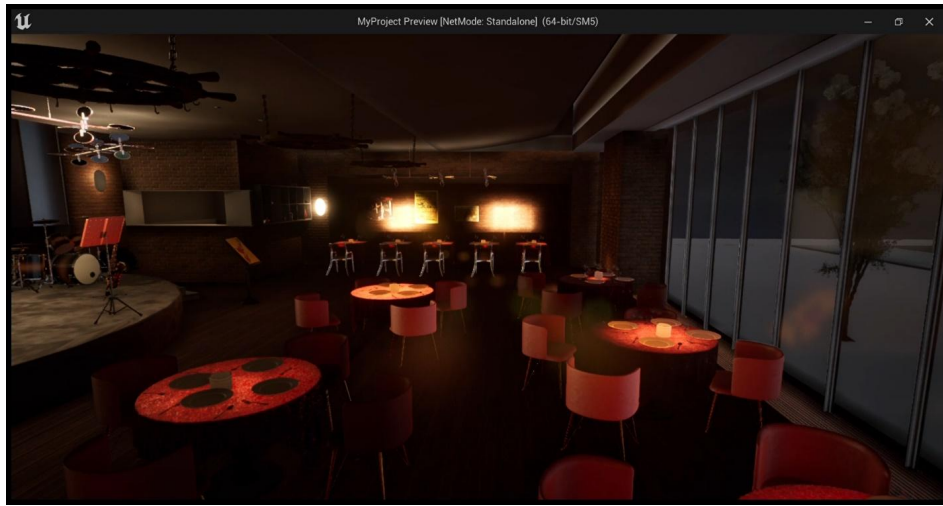
Figure 16: View of the jazz club environment

space and the ambiance of a cabaret with a street view. Only a few rectangles area lights are used to light up the corner where the skylight could not reach. The environment depends heavily on Lumen and emissive material to light up the space and give it a minimalist and modern restaurant feeling. Lumen provides infinite diffuse bounces, essential in scenes with bright diffuse materials like the white paint and stone floor like a live music and fine dining restaurant.

For the second environment, the screen is set in a jazz club at night, so the skylight is set to evening. In order to create a cozy, tranquil ambiance, some materials on the wall were changed from emissive materials to warmer tones like wood or bricks. Good acoustics, a pleasant atmosphere, and clear sight lines are what we wanted to achieve. A spotlight is used around the stage area to draw attention to it.

5   Technical Implementation

This chapter describes the technical implementation of the various features currently present in the Jazz History Database Virtual Museum.

5.1 Movement

There are two ways to move around the environment in the Virtual Museum: teleportation and continuous locomotion. To teleport, the user holds the trigger on either controller. An arc will appear from that hand, and when the player releases the trigger, they will teleport to the location that the arc touches on the floor. Alternatively, the player can use the thumbstick or trackpad on either controller to move throughout the space continuously as if they are walking.

From personal experience, we knew these two types of locomotion are present in various VR applications. There is also a third type of locomotion used in VR known as redirected walking. However implementing this imposes limitations on the sizes of the play space and virtual environment and involves significant and complex changes to how user input is processed (Langbehn et al., 2017), so we decided not to implement that form of locomotion. For the previous two types, continuous locomotion was more likely to cause motion sickness to users than teleportation (Langbehn et al., 2018). For that reason, we decided to implement both types of locomotion. That way, users could decide how they wanted to move around the space, and users could opt entirely out of continuous locomotion if it caused them motion sickness.

5.1.1 Continuous Locomotion

To control continuous locomotion, the player can use the joystick or touchpad on either of the controllers. The `VrCharacter` blueprint will read that input and translate it to two vectors to be added to its current position for every frame that a directional input is given. One vector is the contribution from the x-axis of the controller and the other is the contribution from the y-axis.

Unreal Engine provides `InputAxis` events that are triggered every frame and return a number representing the current position of the joystick or the current position being touched on the touchpad along an axis. For example, the `InputAxis MovementAxisLeft_X` event shown in Figure 17 returns the value of the x-axis position of the left joystick or touchpad. To translate that value to a movement, we first multiply it by a scaling factor (in this case 5) to control the speed of the movement, then we multiply it by the right vector of the controller. The right vector of the controller is a unit vector pointing outward from the right side of the controller. Multiplying the x-axis value by this vector results in a vector with a magnitude equal to the x-axis value multiplied by 5 pointing out of the right side of the left controller. (This means that, in the case where the x-axis position is negative, the vector will be pointing out of the left side of the left controller.) A similar process is followed for the y-axis with the value instead being multiplied by the controller's forward vector, which is the unit vector pointing out of the front of the controller. This will produce a vector pointing either out of the front or the back of the controller, with the magnitude determined by the value of the y-axis input by the player. Together, these vectors represent the direction to move the player on the frame that the two `InputAxis` events are called. The same process is used for the x- and y-axes of the right controller, allowing the player to use either controller for continuous locomotion.

After calculating the movement vectors, there is an additional section that plays the footstep sound if there is movement input. This section is shown in Figure 18. This section reads the joystick input directly, and if any of the joystick inputs is nonzero, the footstep sound cue is played. Since the joystick values are floats, we actually need to check if the values are in a small range around zero rather than just checking if they are zero. This is made easy by the `Nearly Equal` function provided by the Kismet Math Library. We use the `Do Once` nodes to make sure that the sound cue is only started or stopped on the first frame that the player goes from not moving to moving or vice versa. This way, the sound cue is not newly started every frame, and instead plays normally until the player releases all continuous movement input.

Figure 19 shows the footstep sound cue controlled by the blueprint section in Figure 18. This sound cue consists of 9 slightly different single footstep sounds that are randomly played one after another while the sound cue is playing. This is much better than having a single footstep sound or a consistent loop of sounds, since this adds variety to the footstep audio that prevents it from feeling repetitive.

5.1.2 Teleportation

Figure 20 shows the section of the `VrCharacter` blueprint responsible for generating the teleportation arc out of the left hand and calculating the position to teleport the player from that arc. (The logic for the right hand is almost identical.) When the player holds the trigger, this blueprint will call the
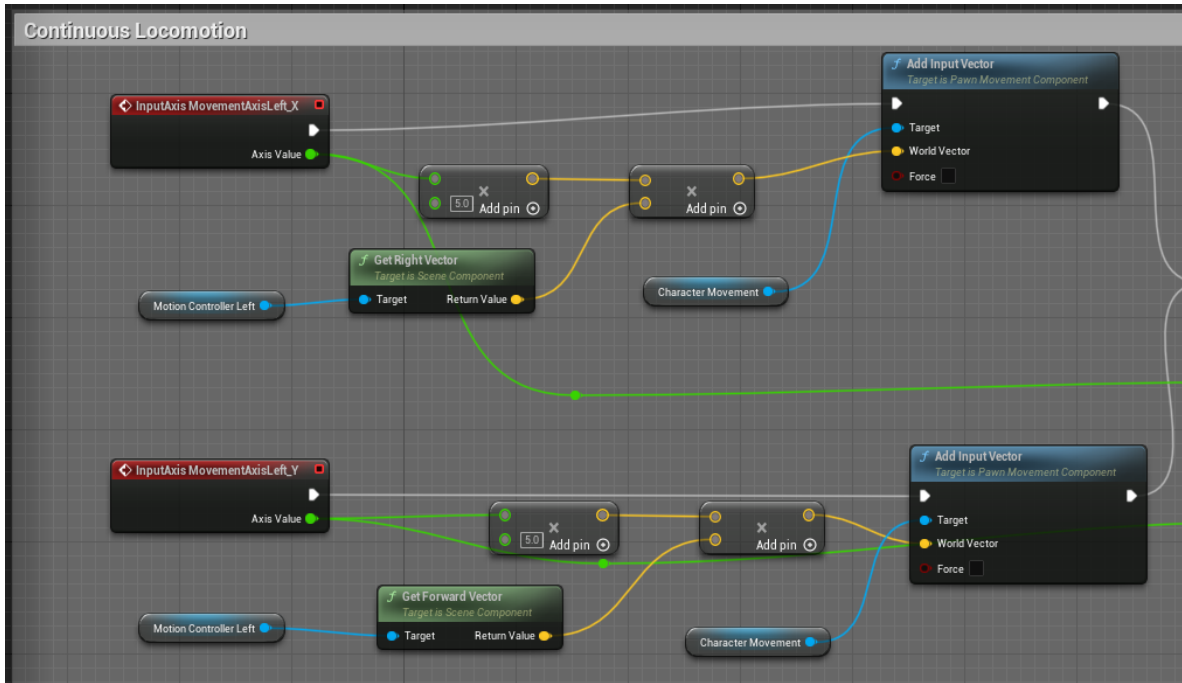
Figure 17: Blueprint section used to control continuous movement from the left controller
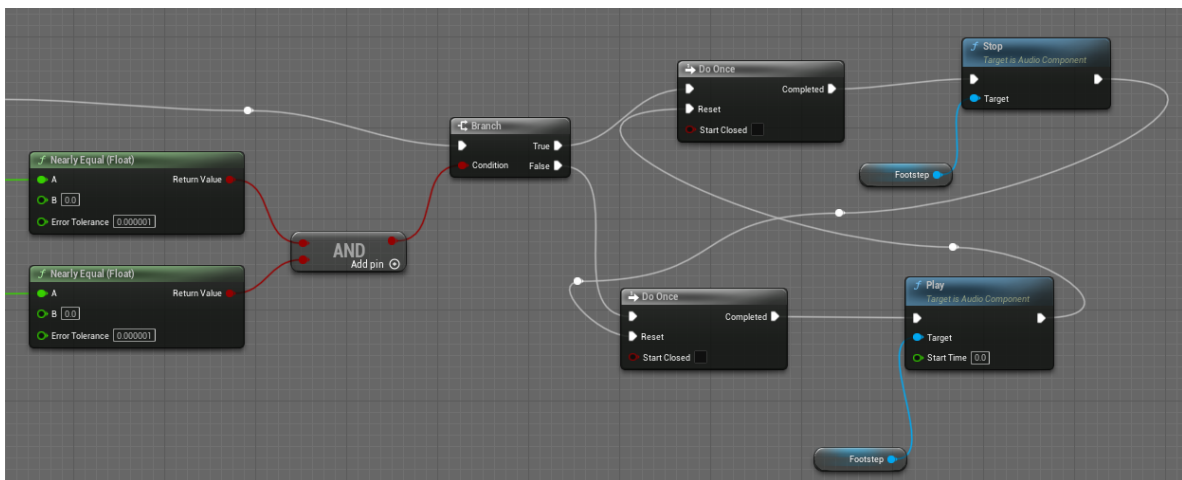
Figure 18: Blueprint section used to control the footstep sound produced by continuous movement
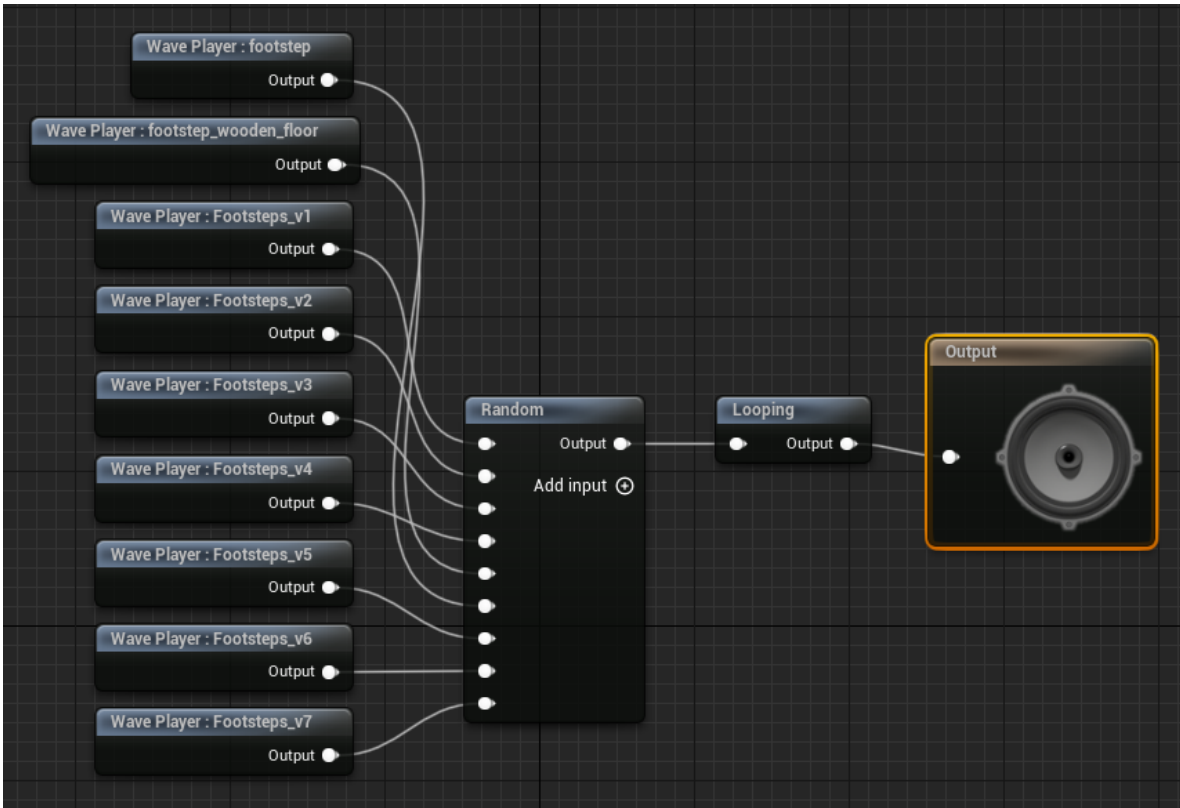
Figure 19: Blueprint of the footstep sound cue

`Teleport Arc` function every frame, which generates an arc indicating where the player will teleport and updates the `Teleport Location` variable. The `Teleport Arc` function takes the location and the forward vector of the controller so that it can generate the arc starting at the controller's position and extending from the front of the controller. When the trigger is released, the `Do Once` block is called, teleporting the player to the vector stored in the `Teleport Location` variable, then clearing the arc generated by `Teleport Arc`. This is only done if the right trigger is not held, since if it is, that means both triggers are held, and the right trigger takes priority.

All of the logic for generating the arc and teleport position is contained within the `Teleport Arc` function. The core of this function is the `Predict Projectile Path By TraceChannel` function provided by Unreal Engine. This function predicts the trajectory of a virtual projectile affected by gravity given the projectile's starting position and launch velocity. While we aren't actually generating a projectile to launch from the controller, this function is a convenient way of generating an arc from
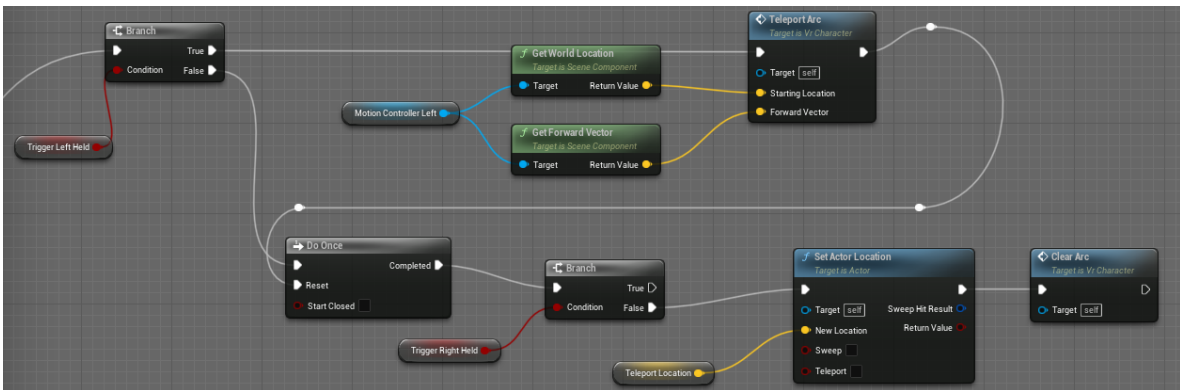
Figure 20: Blueprint of the teleportation logic
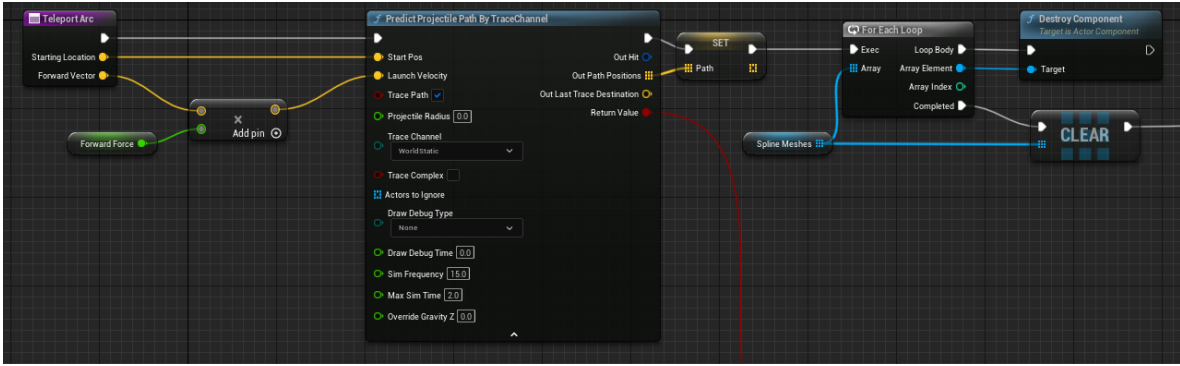
Figure 21: Generation of the teleportation arc's path
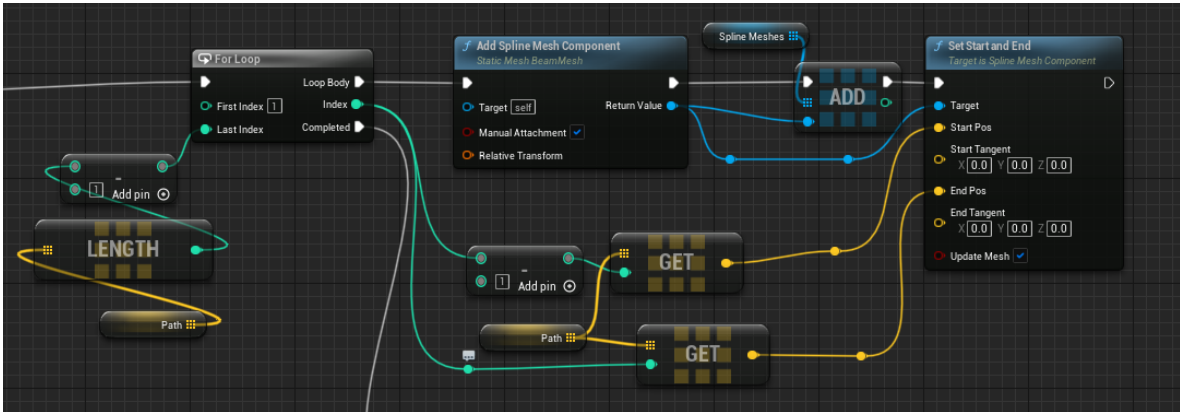
Figure 22: Generation of the teleportation arc's meshes

the controller to indicate the teleportation location. As shown in Figure 21, we give the function the starting location, which is the controller position, and the forward vector of the controller multiplied by a constant force. The function outputs an array of points representing the arc that we save in the `Path` variable. After that, we destroy all of the meshes in the `SplineMeshes` array, then clear it. This array is the array storing the meshes making up the currently displayed arc. This function will generate new meshes for the arc, so we want any previous arcs to disappear to ensure there is at most one arc at a time.

After generating the points along the arc, we loop through points in the path to generate the spline meshes. The loop generates spline mesh components using all of the adjacent pairs of points in the `Path` array. This creates spline meshes in between each pair of points, outlining the arc generated by the `Predict Projectile Path By TraceChannel` function. The section of blueprint responsible for this is shown in Figure 22

Now that we have generated the arc, we now have to identify the teleport location that the arc is pointing to. However, in some cases, the arc may not be pointing to a valid teleport location. If the arc never collides with anything, we know that the teleport location is invalid. So, we can use another convenient feature of the `Predict Projectile Path By TraceChannel` function. In addition to a path, this function returns a Boolean value indicating if the path collided with anything. If this value is false, we know that the arc does not point to a valid teleportation location. So, we can set the teleport location to the player's current position and exit the function. This way, if the player releases the trigger in this case, they will not teleport anywhere.

If the arc does collide with a surface, we need to figure out if that surface is a valid place to teleport. We don't want the player teleporting onto a wall or the ceiling, nor do we want them teleporting into an object. This is where navigation meshes come into play. In Unreal, generating a navigation mesh is quite easy. We simply needed to create a `NavMeshBoundsVolume` to specify where Unreal Engine should generate a navigation mesh. This bounding volume was made to surround the floor and stage, but not any higher. Unreal then generated a navigation mesh on any surfaces inside the bounding

24
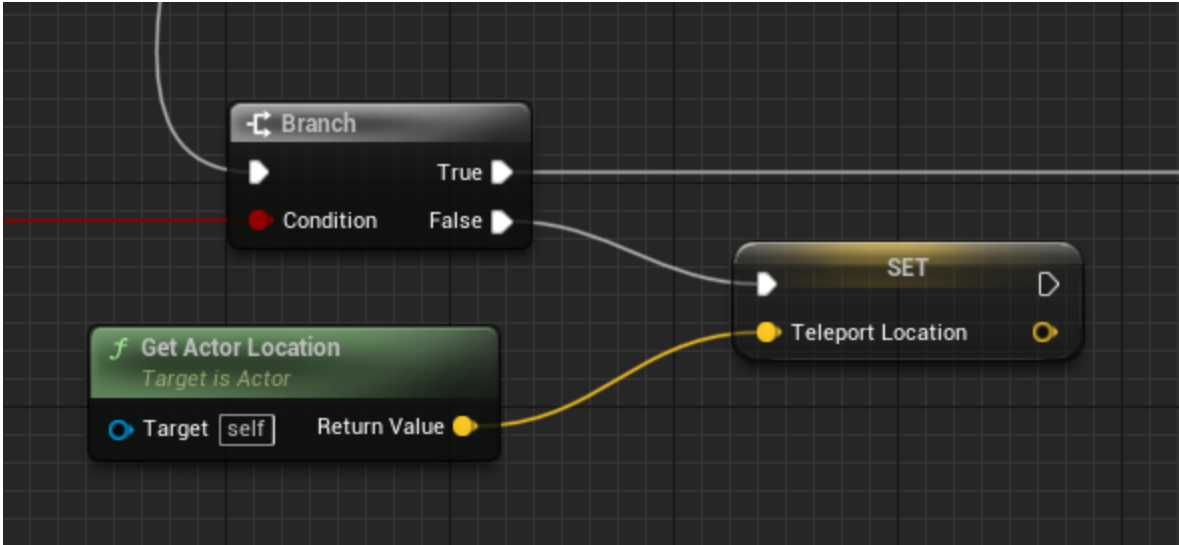
Figure 23: Check for arc collision (The condition input into the branch comes from the path generation function)

volume with a normal vector pointing up within a certain range of angles (i.e. surfaces that are "flat" or below a given angle). The result is a navigation mesh covering only the floor and stage, as shown in Figure 24.

We then used that mesh in the `Teleport Arc` function to determine the teleport location and whether the location is valid. We get the last point in the Path array, and use the `ProjectPointToNavigation` function to convert it to a point in the navigation mesh as shown in Figure 25. The `ProjectPointToNavigation` function returns the projected location and a Boolean value to indicate if the projection was successful. If the projection was not successful, we know that the point the arc points to is not in the navigation mesh, and thus is not a valid teleportation point. So, we do what we did previously and set `Teleport Location` to the current location of the player. If the projection was successful, then we know the point is valid. From there, we can set the teleport location to the point returned by `ProjectPointToNavigation`, adjusted by the location of the camera relative to the `VrCharacter`. Then, as stated earlier, the player will teleport to that teleport location when the trigger is released.

5.2   Grab and Release

The grab and release functionality in the Virtual Museum is designed such that it is easy to specify which objects can be grabbed and which cannot. To make an object grippable, it simply needs to implement `GrippableInterface`. From there, the object can define special behavior when it is grabbed and released. This subsection describes the current implementation of `GrippableInterface` and how the `VrCharacter` handles grabbing.

5.2.1   GrippableInterface

Every object that can be grabbed by the player must implement `GrippableInterface`. This interface provides two events to the implementing object: `Grab` and `Release`. These events are self-explanatory: `Grab` is triggered when the object is grabbed, and `Release` is triggered when the object is released. `Grab` additionally returns the component that initiated the grab event, which will be one of the controllers.

Each grippable object is responsible for handling its own grabbing and releasing logic. For most grippable objects, the logic shown in Figure 26 is used. This makes the object attach itself to the grabbing controller when it is grabbed, then detach itself when it is released. Afterward, most objects then execute some custom logic. For example, instruments play a sound (see Section 5.4 for details). However, the attaching logic is not necessary to include in every grippable object. Not including it is useful if an object needs to execute some custom logic when it is grabbed without being moved. In

25

Figure 24: The navigation mesh used for teleportation (a similar mesh exists in the other map)
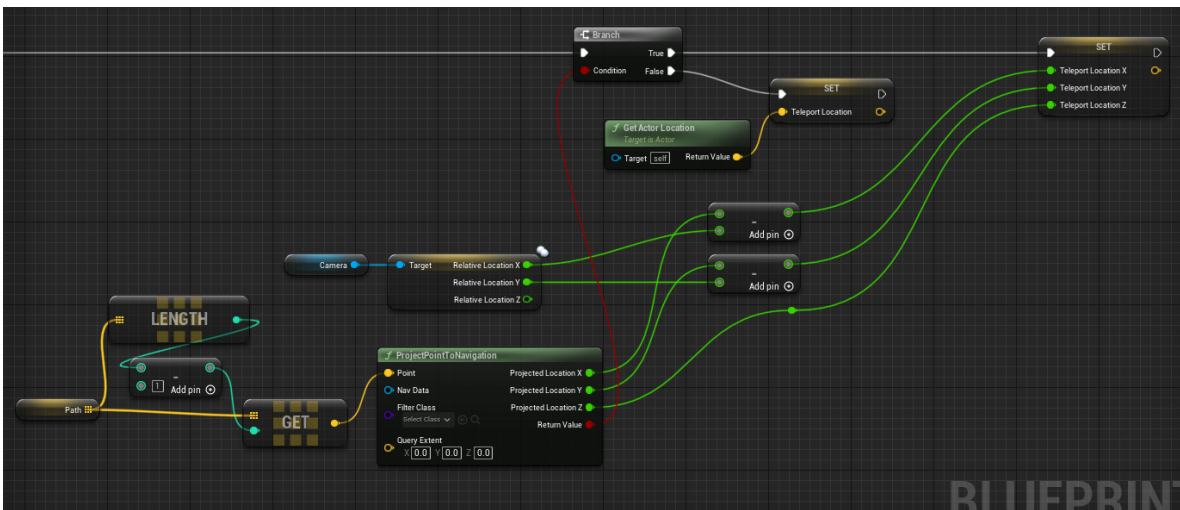
Figure 25: Using the navigation mesh to generate the teleport location
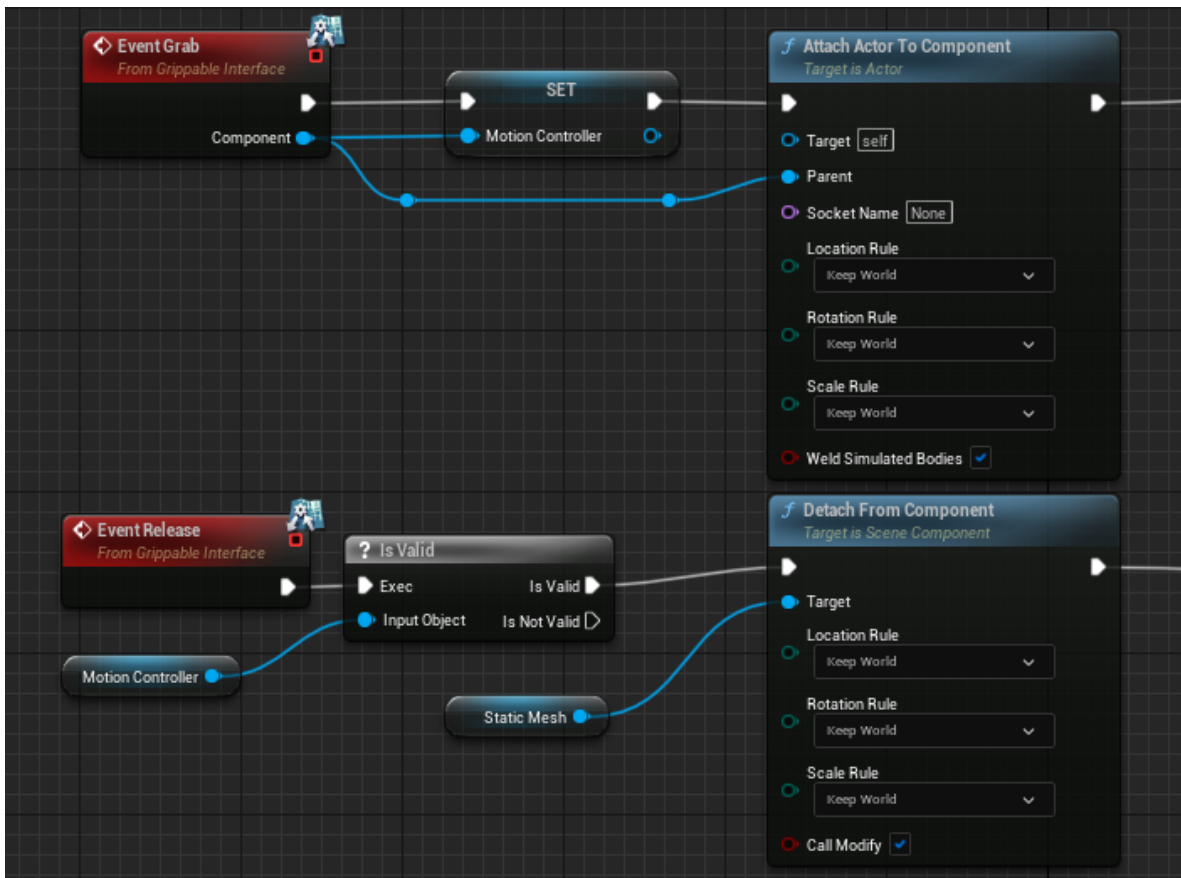
Figure 26: Logic used for an object to attach itself to a controller

addition, this logic could be modified to add grip points to objects. Currently, objects do not have grip points, but future groups could add grip points to objects by adding the logic to handle them here.

5.2.2 `VrCharacter` Logic

The `VrCharacter` is responsible for detecting grippbale objects and triggering the `Grab` and `Release` events on those objects. In addition, it triggers the hand animations detailed in Section 5.3. The blueprint section responsible for this is called using Unreal Engine's `InputAction GrabLeft` and `InputAction GrabRight` events. These events provide two `Exec` outputs. One is triggered when the button is pressed, and one is triggered when the button is released. We will look at the logic for the left hand, which is nearly identical to the logic in the right hand.

The first step that is done in both the pressed and released events is to set the animation state of the hands, as shown in Figure 27. This will close or open the hand. Then, in the released section after the hand state change, the blueprint will check if the object currently being grabbed is valid, then trigger the `Release` event on it if it is. This check is necessary because this event is also triggered when the player releases the grab button after not grabbing anything.

Calling the `Grab` event is a bit more complicated than the `Release` event. The `VrCharacter` needs to find one object that can be grabbed inside the hand's grab radius if there is one, then call the `Grab` event on it. This logic is shown in Figure 28. Each hand has an invisible sphere that defines its grab radius. When the grab button is pressed, `VrCharacter` finds all of the objects overlapping that sphere. Then, it loops through those objects until it finds one that implements `GrippableInterface`. Once it finds one, it calls the `Grab` event on that object, then saves that object in `Grab Left` for use in the releasing logic.
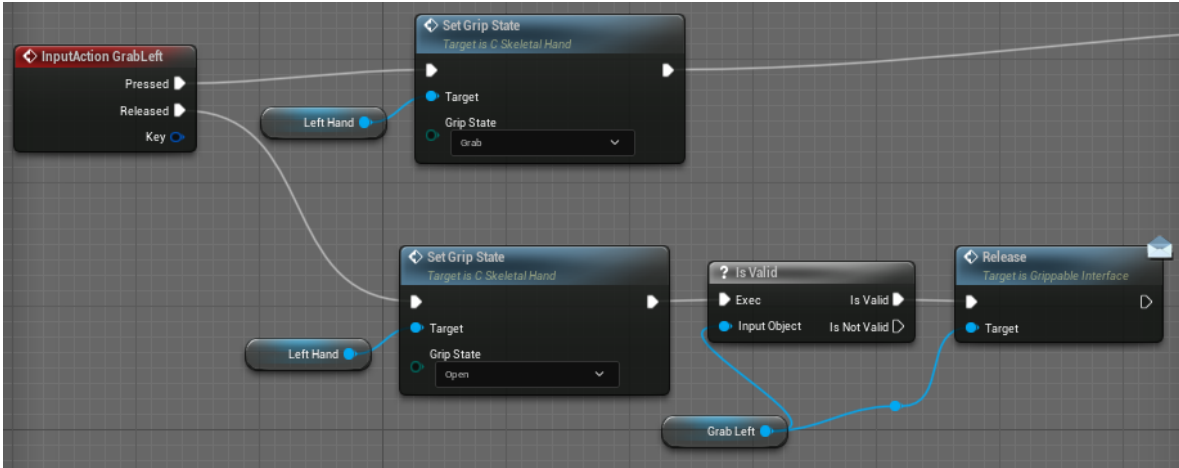
Figure 27: Changing the animation state of the hands, calling the `Release` event
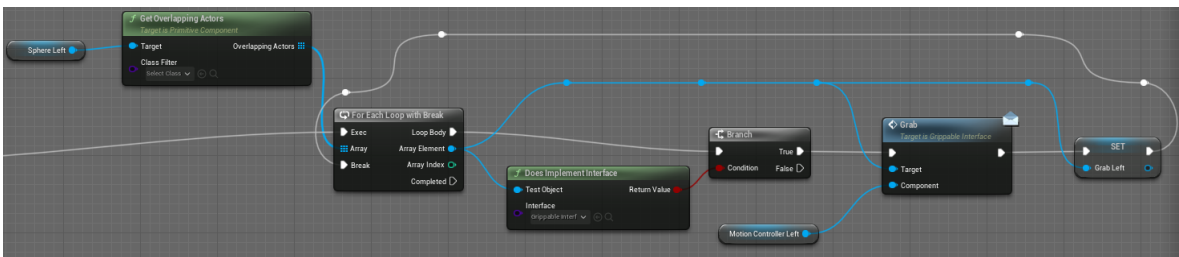
Figure 28: Calling the `Grab` event

5.3 Hands

Instead of using the default controller models provided by Unreal for representing the position of the user's hands, we decided to use a model of a hand with a grabbing animation generated by Unreal. This way, the application would be more consistent across platforms, since each platform no longer needs to have separate models for each type of controller. In addition, it gives users more feedback indicating when the grab input is being pressed.

When `VrCharacter` is created, it calls the `Set Hand` event on each controller. This sets the proper hand mesh for each controller. Then, when the player presses or releases the grip button, `VrCharacter` triggers the `Set Grip State` event with the proper state and hand. The state is denoted using an enumeration called `E_GripState`, that can be either `Open` or `Grab`. The `Set Grip State` event then passes this value to the animation blueprint for that hand, which then changes the animation state for that hand. All of this logic is contained in the `Content/VRTemplate/VRHands` folder.

5.4 Instrument Sounds

Each instrument has its own sound associated with it when it is picked up. This sound is stored in the instrument object and played using the `Grab` event from `GrippableInterface`. After the typical logic for grabbing detailed in Section 5.2.1, the instrument's blueprint executes the section in Figure 29. `Soundwave` contains the sound associated with the instrument, which can be changed from the Details panel of the instrument in the level editor. The blueprint spawns an Audio Component that is saved, then stopped when the player releases the instrument.

5.5 Level Switching

The Virtual Museum contains two environments that the player can switch between by grabbing the jazz poster to the right of the stage. This poster contains a `LevelChangingObject` that calls `Open Level By Name` with the level name set in the level editor. Again, the `GrippableInterface` makes
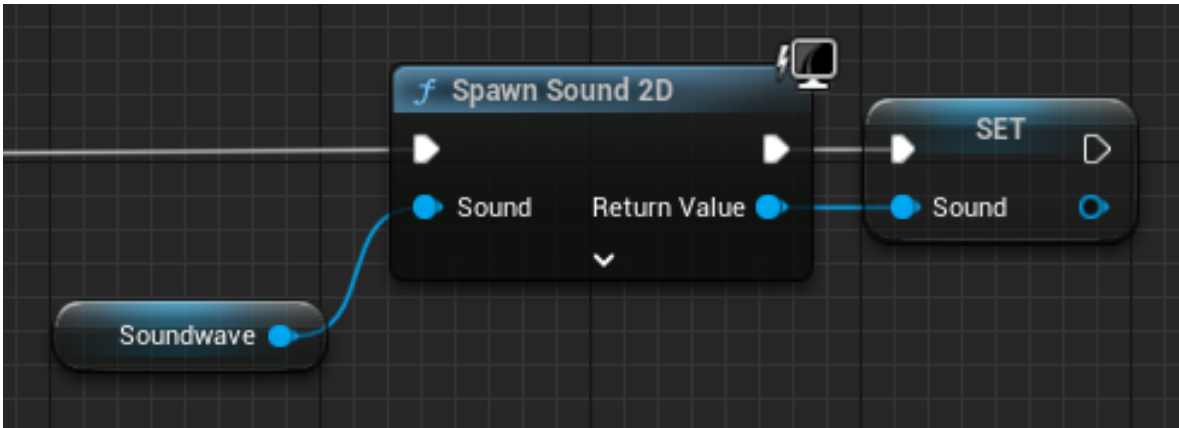
Figure 29: Playing an instrument's sound
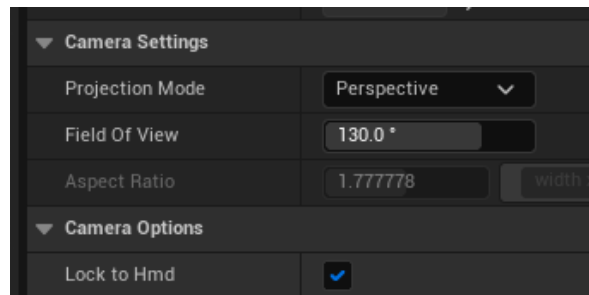
Figure 30: Camera settings for VR camera

this easy, since this just has to be called when the `Grab` event is triggered.

5.6 Camera

5.6.1 VR Camera

The camera for VR mode is attached to the VR character. The Field of View is set to 130 degrees to replicate the field of view of humans in real life. The camera's height is configured by the height of users so that users can move smoothly inside the environment.

5.6.2 Inspector Mode

Even though our project is designed for a VR-based environment, we wanted to make the application accessible for other platforms, not just VR. An inspector is implemented to make the application available to use on Windows without a proper VR device. Users can move around the environment using a keyboard and mouse. Unlike normal VR spectators in other VR applications, this spectator is a stand-alone camera allowing users to inspect the environment using first-person view and move around.

There are three main components to the VR Spectator Camera: Screen Texture, Mode, and Blueprint. The main component to notice is the `SceneCaptureComponent2D` inside the `VRSpectator` Blueprint. This `SceneCaptureComponent2D` is linked to the Target Renderer of the Screen Texture. This means the `SceneCaptureComponent2D` takes a screenshot of each frame and renders it on the users' viewport.

The movement of this camera is mapped using typical first-person controls. Use the W, A, S, and D keys to move and use the mouse to look around. To activate Spectator view, users must use the "Tab" key on the keyboard to switch from `VRGameMode` to `VRSpectator` view.

(a) In the scene

(b) Scene graph
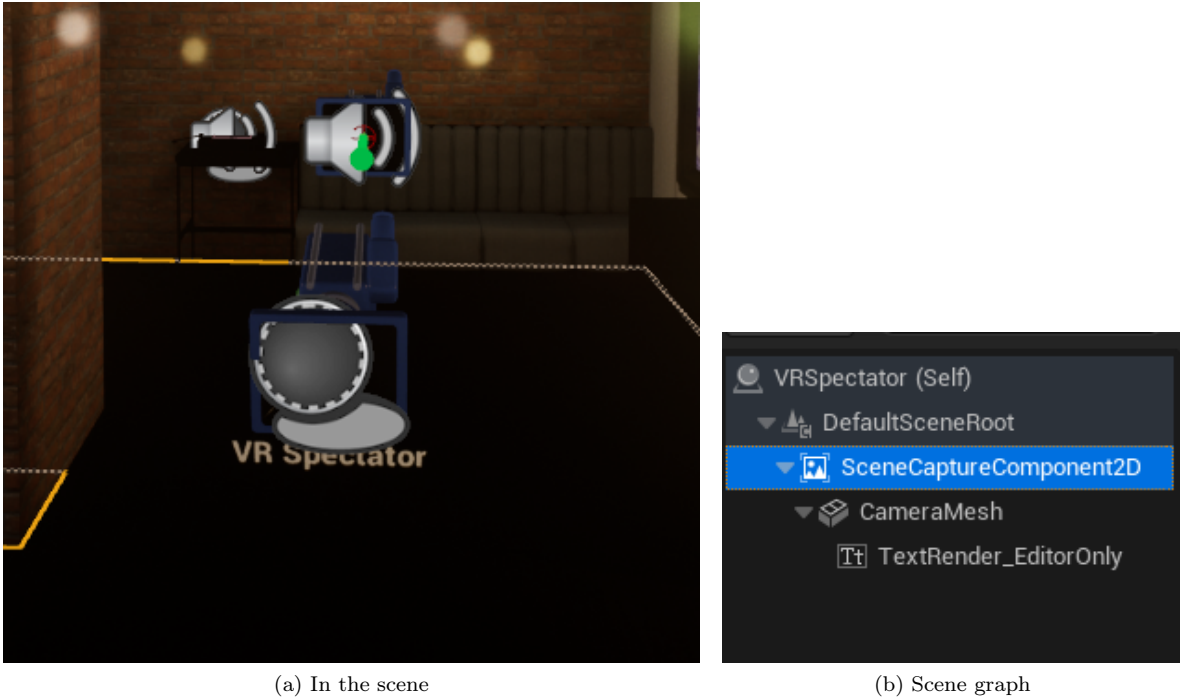
Figure 31: `VrSpectator` in the editor

6 Audio Implementation

This section describes the sound design for the JHDB Virtual Museum. As this project aims to connect jazz to more audiences, the job of an audio engineer is to incorporate jazz into the environment and enhance the current experiences. In this experience, sounds create a realistic and immersive virtual museum experience.

The museum required audio that not only fit the aesthetics of the environment but also was engaging and set the atmosphere for the surroundings. This audio implementation worked closely with the development of technical and artistic elements of the museum to make the experience as immersive as possible.

6.1 Audio Inspiration

VR Seat is a product created using Three.js Library, acting as a middleware between indoor theater concert companies and ticket buyers. The VR Seat application created a half-immersive experience for selecting seats in the theater using spatial audio to help the buyer understand how the sound in the room behaves at the selected seat based on distance and angle. The team wanted to utilize the same design for our space based on the user's location; they have different qualities of sounds and different types of sounds coming. We determined that this sound design choice can help this experience become more immersive and closer to a real-life experience.

6.2 Audio Tools

Several programs were used to generate the audio library for this experience. We were provided recordings and audio files by Ben Young from the JHDB to make the experience immersive and represent the JHDB. Other sound like sound effects or ambiance were downloaded from freesound.org or created using Reaper by the team. Some were edited in Audacity or Reaper to fit the need of the projects. These two audio tools were available for free, and team members have the licenses for the Professional version of Reaper.
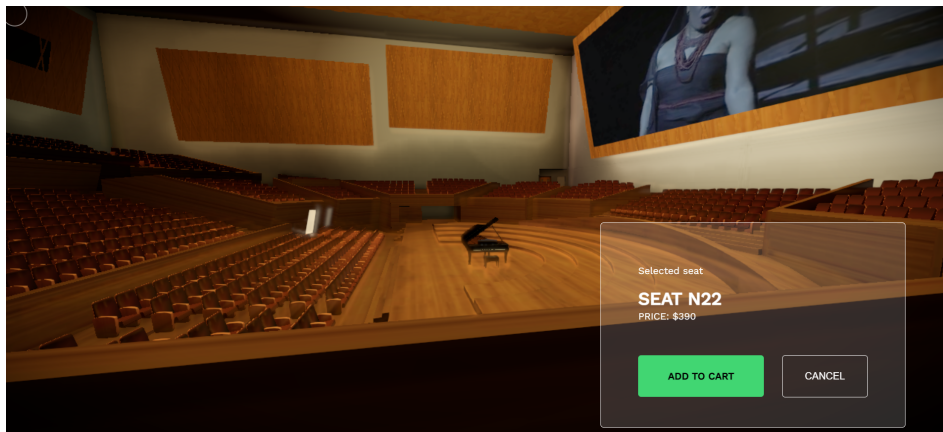
Figure 32: Screenshots of the VR Seat application (https://vrseat.vercel.app/)
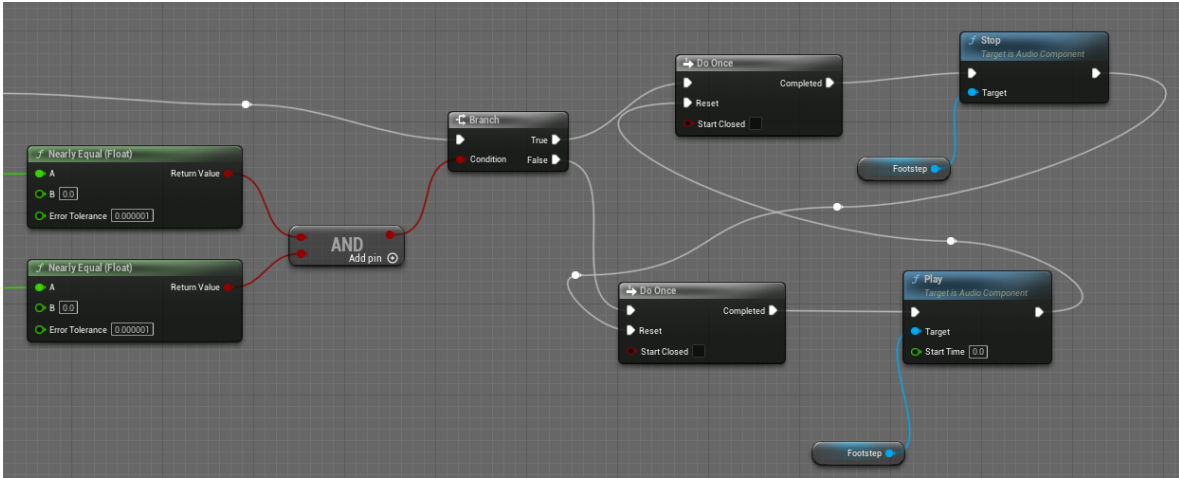
Figure 33: Blueprint section used to control the footstep sound produced by continuous movement

6.3 Sound Effects

Sound Effects in the JHDB Virtual Museum broke down into three main effects: footsteps for locomotion, grabbing/drop sounds, and musical instrument sound effects. Most sounds were initially sourced from freesound.org, a website where anyone can download free sound assets. Some sounds were extracted from the tracks sent to us from the JHDB. The sound effect process consisted of downloading or extracting the sounds. Then, we cut and edited the sounds, equalizing them and removing noise. Lastly, we converted them to WAV because this is the only audio file type Unreal Engine 5 supports without plug-ins.

Footstep sound effects are required to offer an immersive experience for people using continuous locomotion. Multiple good step sounds with similar frequencies were cut and mixed randomly in Unreal Engine, so when users use continuous locomotion to move around, no same footstep was playing twice in a row to replicate the inconsistency of sound in the real world.

Once the sounds were created, they were implemented into the game as a sound cue for an audio source. After calculating the movement vectors, an additional section plays the footstep sound if there is movement input. This section is shown in Figure 33. This section reads the joystick input directly, and if any of the joystick inputs is nonzero, the footstep sound cue is played. Since the joystick values are floats, we need to check if they are in a small range around zero rather than just checking if they are zero. This is made easy by the Nearly Equal function provided by the Kismet Math Library. We use the Do Once nodes to ensure that the sound cue is only started or stopped on the first frame that the player goes from not moving to move or vice versa. This way, the sound cue is not newly started every frame and instead plays usually until the player releases all continuous movement input.

Figure 34 shows the footstep sound cue controlled by the blueprint section in Figure 33. This sound cue consists of 9 slightly different single footstep sounds randomly played one after another while the sound cue is playing. This is much better than having a single footstep sound or a constant loop of sounds since this adds variety to the footstep audio, preventing it from feeling repetitive.

6.4 Ambiance & Music

The JHDB representative, Ben Young, gave us the original background music. However, if we only have music in the background, the experience might appear flat and one-dimensional to users. To make it immersive, we use spatial sound provided by Unreal to make the experience as realistic as possible. A mix of a jazz soundtrack and ambiance sounds like a dine-in live entertainment establishment or museum ambiance was used to mimic the atmosphere at a contemporary museum or a restaurant.

Instead of one big spatial sound cue in the environment, the sound cue broke down into different area spatial area sound cues. This technique allows us to create a situation in the real world where users hear more dining ambiances or more of the performance based on where they stand.

Figure 36 shows the setup of 3D spatial sound in Unreal Engine 5. To allow 3D sound, we enabled Volume Attenuation. This setting specifies how the sound becomes quieter (attenuated) the farther
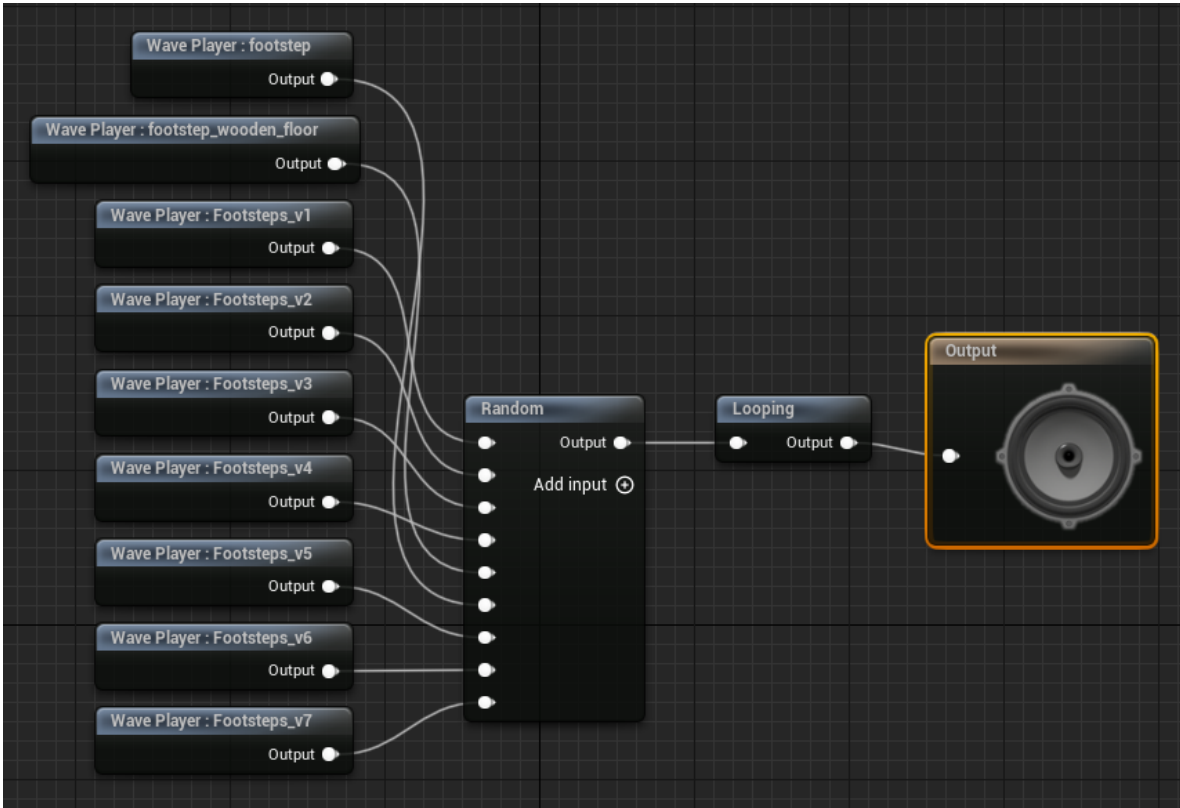
Figure 34: Blueprint of the footstep sound cue
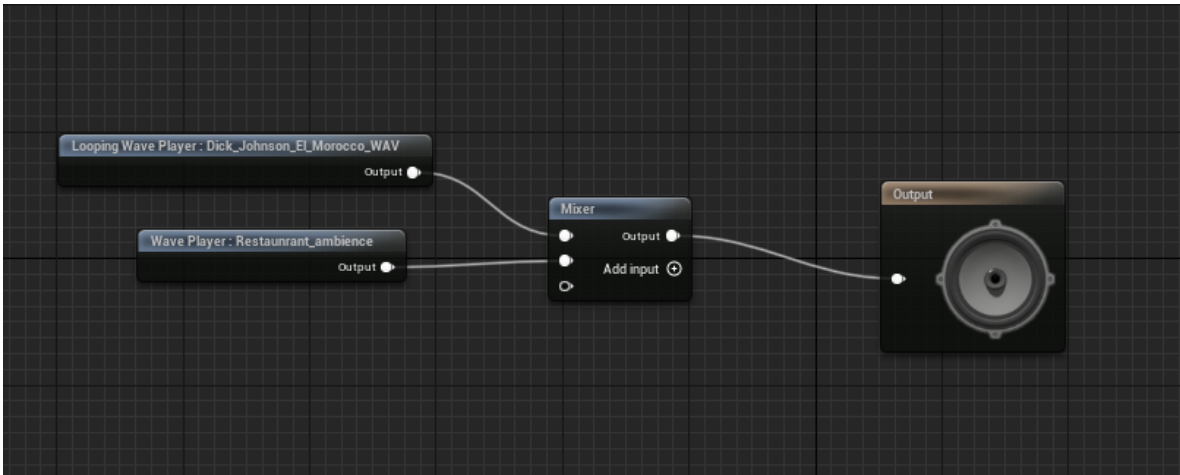
Figure 35: Blueprint of the ambiance sound cue
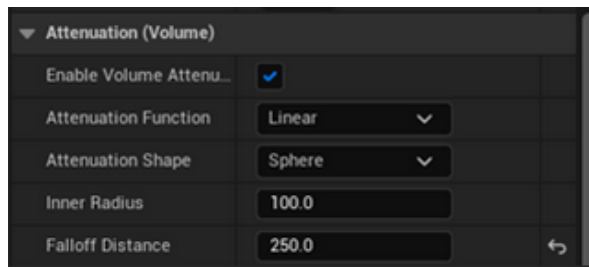
Figure 36: Attenuation settings for the ambiance sound cue
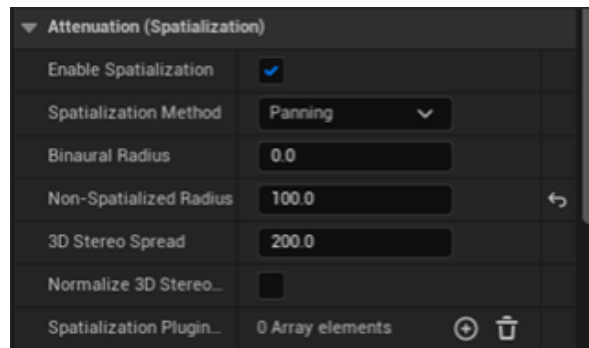
Figure 37: Spacialization settings for the ambiance sound cue
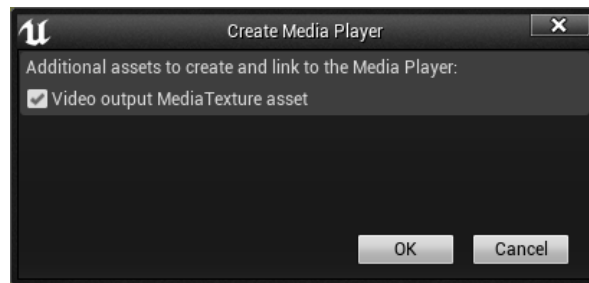
Figure 38: Create Media Player message in Unreal Engine

the listener gets from it. The inner region of the attenuation form is where the sound will be loudest. The sound becomes quieter as the listener goes out of this inner area, reaching its quietest point at the edge of the outer area. The attenuation function established the rate of attenuation to distance. The attenuation shape was set to the sphere, essential in recreating a realistic experience because it models how sound propagates in the real world. We wanted to have different areas of sound, so the inner radius and fall-out distance were set to a relatively small number so that users could still hear the sounds when far away, but this does not affect their primary active listening process. These can be changed based on the purpose of the area sound.

We also enabled Spatialization to help us integrate the sound with our environment. With it enabled, the sound is spatialized from a specific location within our world and panned accordingly as the listener moves around. We also set the non-spatialized radius to 100.0, and this was to prevent sudden and jarring switches between spatial sound and 2D sounds when the users approached the sound sources. This also helped with the problem of uneven audio for headphones users, as when they get closer, the sound switches to 2D and distribute evenly in both headphones.

6.5 Video and Interviews

During our project's development, we realized our sponsor's mission is about jazz history and the figures and story behind it. The JHDB has an extensive database of interview recordings of notable figures in jazz history. Per our request, our sponsor provided us with some of those interview recordings.

To stream a video in Unreal Engine 5, we needed to convert the video into an Unreal-Engine-accepted file type. Since Unreal Engine 5 can only read the ".mp4" file without add-ins, we converted all the files into ".mp4" type and imported it as a file in the Movies folder. It was essential to import them into the "Movies" folder so that Unreal Engine doesn't import the file as a texture. From there, we can create a Media Player from the video. We created a Media Texture and Material for the video from the Media Player.

We created a Blueprint named `BP_TV` to play media and interviews for our environment. The viewpoint and hierarchy of this blueprint are shown in Figures 39 and 40. A Static Mesh with a flat surface like a Plane was needed to project the video texture. After replacing the surface material with video texture, we also needed to make sure that sound from the video player was along with the texture. To do so, we attached an audio source with the static mesh. This audio source is taken from
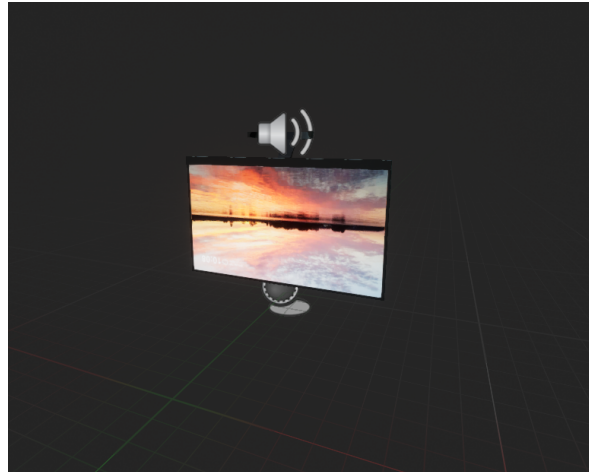
Figure 39: Model of the television used to play interviews in the environment
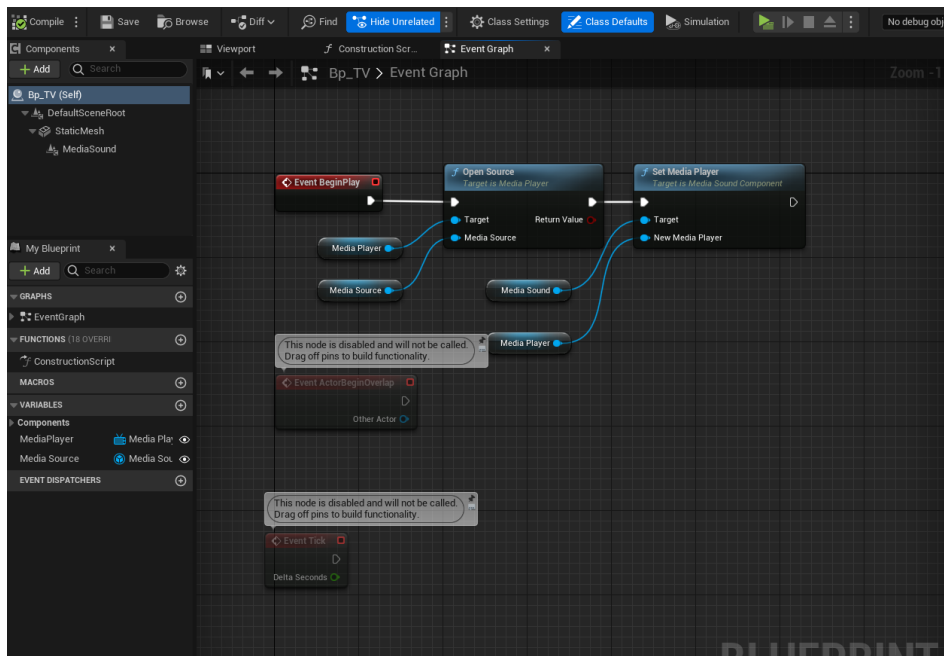
Figure 40: Blueprint of the television

On a scale from 1 to 5, what is your level of experience with Virtual Reality?
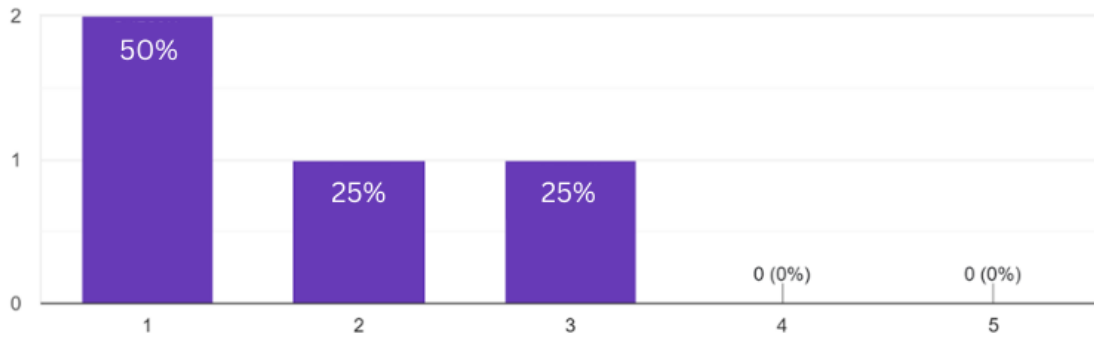
Figure 41: Survey results for level of user experience

the original imported media file. The audio source also allows us to make the sound spatial rather than flat 2D from the media file. The attenuation of the interview was set lower than the other ambiance sounds so that users have to get closer to hear the TV. This blueprint's static mesh and an audio source are made public so developers can easily manipulate the content for future development.

7   User Testing & Analysis

Throughout the development process, the team conducted two surveys, one as secondary research on the audiences and one user usability section during the IMGD-sponsored AlphaFest event. The first was to understand our user's perspective; the second was to measure the overall accessibility and experience for improvement in the future. The playtest session concluded with an anonymous survey of users.

7.1   Protofest Preliminary Research

Protofest is an event hosted by the WPI IMGD department in which MQP teams present their initial ideas to participants. We used this opportunity to research our target audience to learn more about the user's perspective.

We first want to learn about the general public's experience level with Virtual Reality. We asked the participants to judge their familiarity with Virtual Reality on a scale from 1 to 5, where 1 is the least experience, and 5 is the very familiar with the technology.

As seen in Figure 41, 50% of participants report choosing 1 as their answer, while the other part of participants divided half into choosing 2 and 3. None of the participants chose 4 or 5. These responses showed that, even in a group of people familiar with interactive media, many people are likely unfamiliar with VR or uncomfortable with the technology. This result is supported by the response shown in Figure 42, where 60% of the participants answered that they had never used VR before, while the others reported using it less than once a month.

We also asked what they thought was an ideal duration for a VR session. Because most participants said that they had never tried VR before, this led to many "I do not know" answers. We do have a 20-minute response and a 5-minute response. Based on our additional research on the duration of VR games, for games that do not involve different movements like Beat Saber or Paradiddle, 20 minutes of interaction is reasonable. However, for those that involve many movements or a museum-like experience, 5 minutes of interaction might be the ideal duration.

The answers are varied when asked what VR hardware participants are familiar with, as shown in Figure 43. This means that our application should target multiple different VR platforms.

All the results from Protofest suggest that we should build an experience that is not too advanced and easy to use, even for non-VR users, and compatible with multiple devices.

About how frequently do you use VR?
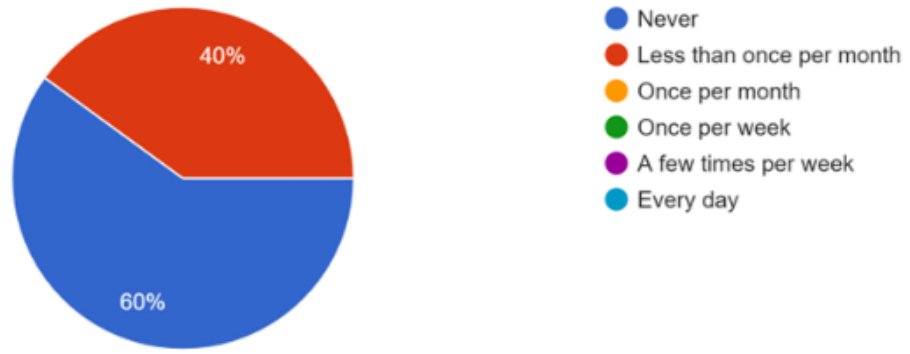
Figure 42: Survey results for frequency of VR usage

What VR hardware are you familiar with? (Similar hardware is grouped together, i.e. Meta Quest includes the Quest, Quest 2, and Quest Pro)
4 responses
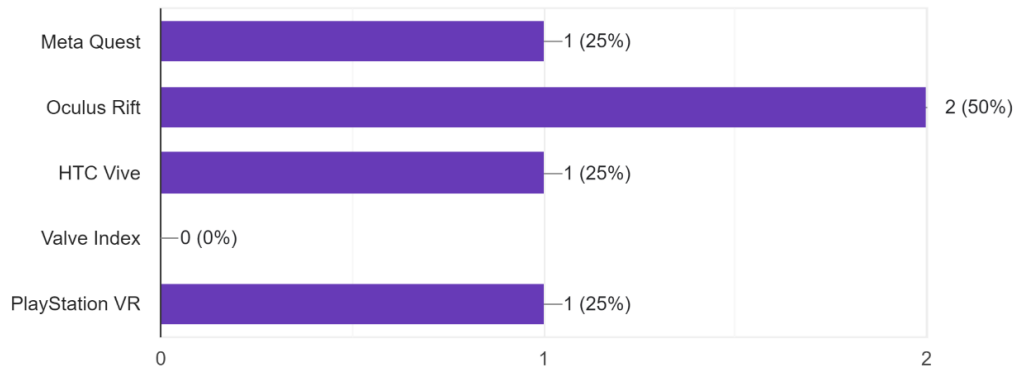
Figure 43: Survey results for familiarity of various VR platforms

7.2 Alphafest

Alphafest is an event hosted by the WPI IMGD department where students can show their progress on their MQP to everyone who attends. Alphafest is a great time for a team to test their alpha build, the first version of their game or application, which does not always have the full features implemented and refined. When the team participated, all the intended main interactions were implemented while the game's environment was greyboxed. The surroundings were just simple art assets with models of instruments. The team created one survey to test and measure the usability of the experience while also asking testers about their ideal environment. Alphafest was valuable for getting feedback from players who did not know about the game or had not tried VR before.

The usability testing happened on the second floor of Innovation Studio, where we had one info table in the Alphafest area and a testing area in Innovation Studio 221 – Global Lab, where most of our development happened. Using this room also ensured that the first build of the museum ran correctly. This room was also suitable for the room-scale environment and other types of VR interaction while providing a safe place that meets both the VR safety guidelines and the COVID-19 protocol for research at WPI. We had an info table at Alphafest providing curious audiences with basic information about the museum while hosting playtesting in another area. We had a video recording, a trailer of our environment, and a banner at the Alphafest to draw attention to our table. A typical testing section was 20 – 30 minutes, due to adherence to COVID-19 protocol and consent forms for both VR usage and collecting data for analysis, while the duration of Alphafest was only 3 hours. As a result, we collected only eight survey responses for the VR museum.

7.2.1 Questions and Expectations

The survey was designed to gather feedback on the interaction in the museum to provide insight into whether these elements needed improvement. Eight questions were targeted to measure enjoyment and get feedback for the spatial movements in VR. For interaction in the VR survey, there were four specific questions on engagement, and two asked for suggestions on VR interaction. The primary goal of the interaction survey was to get the users' thoughts on the interaction level in a virtual museum. We also asked about the playtesters' experience level in VR to determine the target audience.

It was expected that the playtesters would have a certain familiarity with VR technology, given that the general audience of Alphafest was Interactive Media & Game Development majors. We expected most testers would find the system easy to use for the spatial navigation survey. We were also prepared for possible motion sickness situations due to continuous locomotion. For the interaction, we expected to receive neutral responses toward the function as it was implemented in many other VR experiences. Finally, we anticipated that the comments and feedback on the interaction would suggest a more advanced level of interaction than the current system at Alphafest.

7.2.2 Result

7.2.2.1 Target Audience Background

We asked testers if they had tried VR before, and surprisingly, compared to our initial survey in Protofest, 75% of our testers had tried VR before. This answer was a significant change in our research as we designed the museum for first-time or infrequent users due to the result of the Protofest survey.

We also asked the same question on how comfortable they are with VR technology. Contrary to the result of Protofest, most participants in Alphafest were at a certain level of comfort with VR technology. This result is the opposite of our initial research. However, we also knew that our testers were IMGD students or had some gaming involvement. The likeness of them having experiences with VR is significantly higher than our target audiences.

No substantial change was drawn from this area of research, but this made our team consider that more advanced interaction, like a dialog system or narrative system, might be ideal for the future. Section 9 will talk more about ideas that were considered but never implemented.

Have you tried VR before?
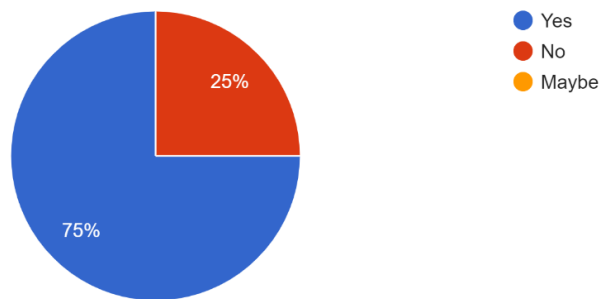
8 responses

Figure 44: Alphafest audience background responses

How comfortable are you with VR technology?
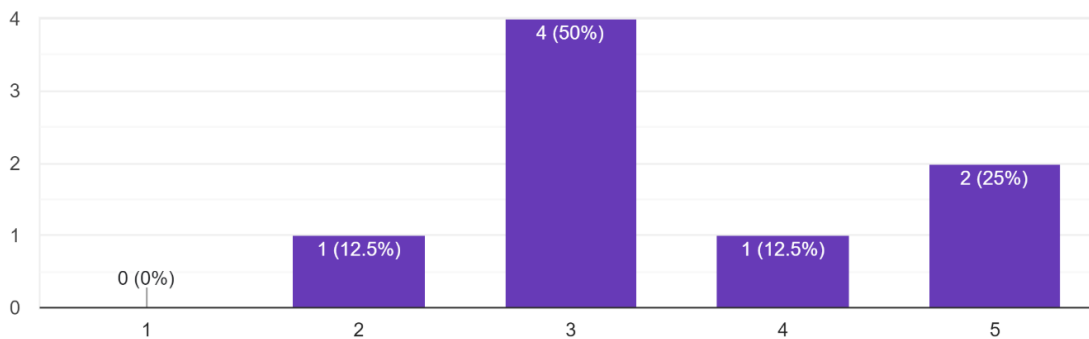
8 responses

Figure 45: Alphafest audience comfort level responses

How difficult is it to navigate through the current level?
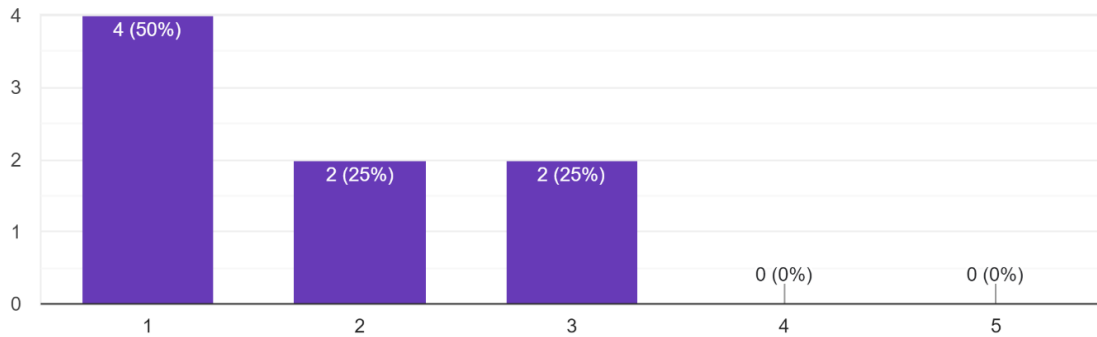
8 responses

Figure 46: Navigation difficulty responses

7.2.2.2 Interaction

We surveyed two ways of movement to see users' preferences and find bugs and areas for improvement. We first asked the users if they faced difficulties navigating through the level. The result is shown in Figure 46.

This showed that our movement and map design implementation is relatively easy to navigate. Two users selected three when asked and reported that they did not find the navigation hard or easy. This also contributed to our conclusion that our navigation system is easy to understand for users. Nevertheless, we believe that adding a hint or manual at the beginning might help users in the future to navigate more effectively.

7.2.2.3 Teleportation

In Figure 47, the chart indicates the result of the survey question on how difficult it was for users to use the implemented teleportation ability. As can be seen in the diagram, none of the testers faced any difficulties in using the teleportation function within this build. Hence, most users found it easy to move using teleportation to navigate around the map.

7.2.2.4 Continuous Locomotion

When asked about the continuous locomotion, a written response was required. We wanted to ensure the features were desirable and provided accessibility to all demographic groups. 50% of the respondents claimed they did not face difficulties, while the other half listed locomotion as practical but too sensitive. They said it moved too fast, and it would be better if we reduced the velocity, or else it might cause motion sickness. We noticed this response and added it to our queue of tasks after the Alphafest. We believe this is a good suggestion. We wanted to try our best to prevent motion sickness because we believe this would affect our user experience to enjoy and explore more.

7.2.2.5 Grab & Release

We also asked users about our implemented grab and release function at Alphafest. Figure 48 shows that the function is relatively easy for most of our audience to use. However, in the Recommendation section of the survey, some testers mentioned that the grabbing and releasing function was quite strange at the time because they could grab multiple objects simultaneously, and users could not move objects from one hand to the other. We identified this issue as the area collision between the hand and the object and reduced it to make the grabbing function work better in the newest build. Additionally, we modified the grabbing function to break after finding one grabbable object to prevent the issue of

How difficult is it to use the teleportation ability?
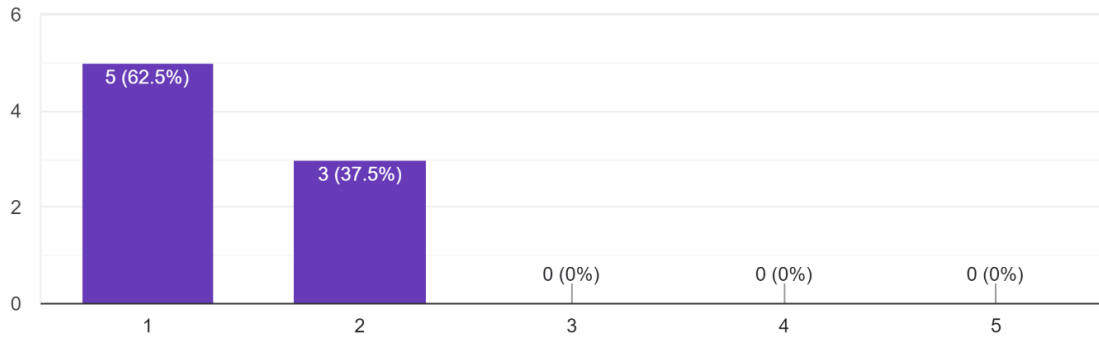
8 responses

Figure 47: Teleportation difficulty responses

How do you feel about the Grab & Release function?
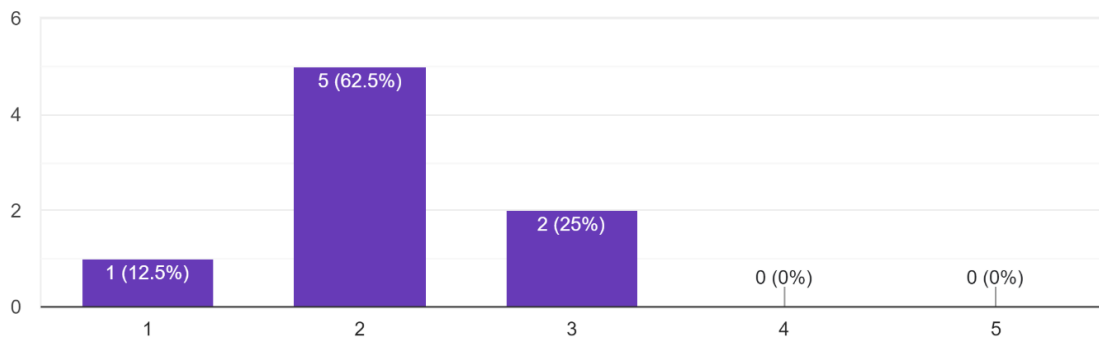
8 responses

Figure 48: Grab & release difficulty responses

What is your preference on Grabbing function?

8 responses

- ● Remain as it is. Hold Grab to held the object
- ● Having the object stay on hold and only be released when press hold again.
- ● Remain as is, but I think you should let go of all objects when holding multiple at a time
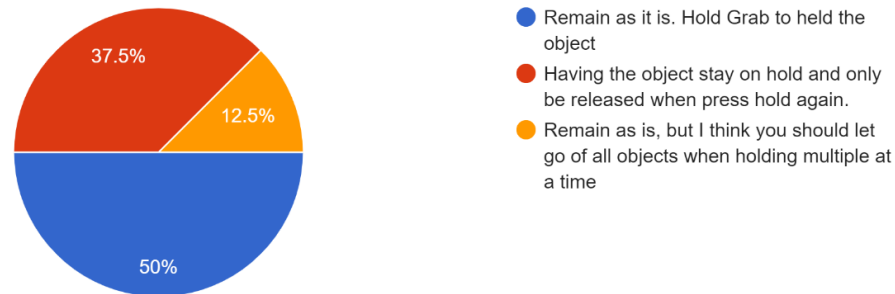
Figure 49: Grab & release preference responses

grabbing multiple objects. We also recognized that grabbing in VR is quite different from the typical first-person or point-and-click game, so we wanted to ask their preference on how grabbing and release functions. The answers are shown in Figure 49.

Half of the testers suggested to keep as it is. We took this suggestion and kept the grabbing controls such that the user has to hold the button to keep holding the object.

All users said that the grab and release function is the most useful function as it was interesting to interact with an object in the museum. They suggest having something to explain the purpose of the instruments and the sound from the instrument when interacting with them, as that can help satisfy player curiosity about specific instruments or other objects.

8   Conclusion

This project initially set out to create a virtual reality museum experience that could help promote and preserve the content of the Jazz History Database. The primary goal of this project is to create a space to welcome those who might otherwise feel that the world of jazz is arduous to enter or intimidating in a way, record the history of jazz, and encourage curiosity to explore and experience the world of jazz more interactively.

The overall experience of the JHDB Virtual Museum features two distinct environments where users can explore different aspects of jazz. We believed that having two different designs of the museum can first differentiate the purpose of the space while also making sure that what we intended to highlight in each environment stands out. This significant design also can accommodate a larger population to attract more interest in jazz.

The experience had two different types of spatial movements and a variety of object interactions. These technical designs were made to provide accessibility to users, prevent motion sickness and give the users the freedom of choice inside the museum. The experience is mainly developed using Blueprint features of Unreal Engine 5, with comments provided for future teams to approach the project.

8.1   Post-Mortem

The 2022-2023 Jazz History Database Virtual Museum successfully translated the goal of creating a virtual environment for the Jazz History Database to preserve and promote content. We also accomplished the goal of making the space accessible via different platforms and documenting the progress for future implementation.

There were a few aspects that we wished were done differently. First was the general project team structure. Our team started with three members, and we lost one member, the artist, who led the structuring of our team's plans. We also did not have an official team leader to lead and organize tasks, leading to miscommunication and project development delays. The second is project version

management. Since we were a small team, no version-managing software was used. So, when merging the changes, we had to reimplement all the functions manually. Due to the project package's size, we needed to meet in person and work together simultaneously to avoid conflict in the version. Lastly, it is about the platform for the project. The progress likely could have moved faster if we approached the project using a different engine and platform than Unreal Engine 5 due to our lack of familiarity with the engine.

Overall, the entire team felt that this MQP was a success. Even though we did not have a dedicated artist, we achieved two different environment designs that conveyed our ideas well. From the technical standpoint, we provided users with an adequate level of interaction to explore the virtual space with fun and educational intention. Based on the results and feedback the team received in person and through written comments, the team felt the target experience goal was met and that this MQP was a project to be proud of.

9 Future Development

We wanted to ensure that future development for the JHDB Virtual Museum would be easier for any student teams who continue this project. As such, we made it a point to document our project workflow; the chapter below thoroughly contains the documentation and recommendations for the future of the Jazz History Database Museum at WPI.

9.1 Documentation for Future Teams

We used the `VR_Template_2` map as the starting point of our project. The main two maps implemented for this project's build are `ModernMap` and `New_Map`. The `VR_Template_2` should be the starting point if future teams want to understand the project. This template included all the basic logic for teleportation, continuous locomotion, VR spectator, and input actions, such as grabbing and interacting with objects.

The current project is compatible with the following devices:

- Oculus through Oculus Link

- Steam VR

  - We tested this using an HTC Vive; functionality with other hardware supporting SteamVR is unknown

The project was build on OpenXR, so it may be compatible with additional platforms that we did not get to test.

9.1.1 OpenXR & SteamVR

The provided template uses OpenXR and SteamVR frameworks to make support for multiple devices easier. Future teams can add more OpenXR and SteamVR plug-ins in Unreal Engine to extend the possibility of this project.

9.1.2 Working with `VRCharacter`, Game Mode

The objects listed in Table 1 determine the rules of the current template experience and how it is set up.

9.1.3 Input

The input for the VRCharacter is mapped based on the HTC Vive headset and the Action and Axis Mappings Input System in Unreal Engine. The mappings are shown in Figure 50.

Figure 50: Input action mappings

UE Objects	Name of Object in VR Template	Location	Description
VR Character	`VRCharacter`	Content > Blueprints	We attempted to make our own VR Character referencing the VR Pawn to ensure that our character works for both HTC Vive and Meta Quest. This character is the physical representation of the user and contains all the logic for user input events from the motion controller.
Game Mode	`VRGameMode`	Content > VRTemplate > Blueprints	This determines which game mode the user is going to experience.

Table 1: Main content of VR Mode

9.1.4 Movement

As mentioned in the Technical Implementation chapter, this template has three types of movements. Teleportation and continuous locomotion are implemented in the `VRCharacter` blueprints and can be viewed and edited using Unreal Editor.

9.1.4.1 Teleportation

To use the teleport functionality:

1. Hold the trigger on one of the motion controllers and point it in the direction you would like to teleport. An arc will appear indicating the teleport location.

2. Release the trigger to teleport to the indicated location.

9.1.4.2 Continuous Locomotion

To move using continuous locomotion, move the motion controller's thumbstick or trackpad in the direction you want to move. The system will move the camera according to this input.

9.1.4.3 Setting Allowed Areas for Teleportation

The level uses a Navigation Mesh to mark where the user is allowed to move. Use the `NavMeshBoundsVolume` actor to set up the area where the navigation mesh will be generated. The green area is the generated navigation mesh where teleportation is possible. Figure 51 shows an example of a navigation mesh generated by enclosing the ground in the `NavMeshBoundsVolume` actor.

9.1.5 Grab & Release

We implemented the functionality allowing users to pick up objects. To grab an object in the level:

- Reach out to a grabbable object, then press and hold the Grab button on the motion controller.

- The motion controller has a Sphere Trace Collision around its position. If an Actor implementing `GrippableInterface` is in that sphere, it becomes attached to the hand that pressed the Grab button.

- Release the Grab button on the same motion controller to detach the object from the VR hand.
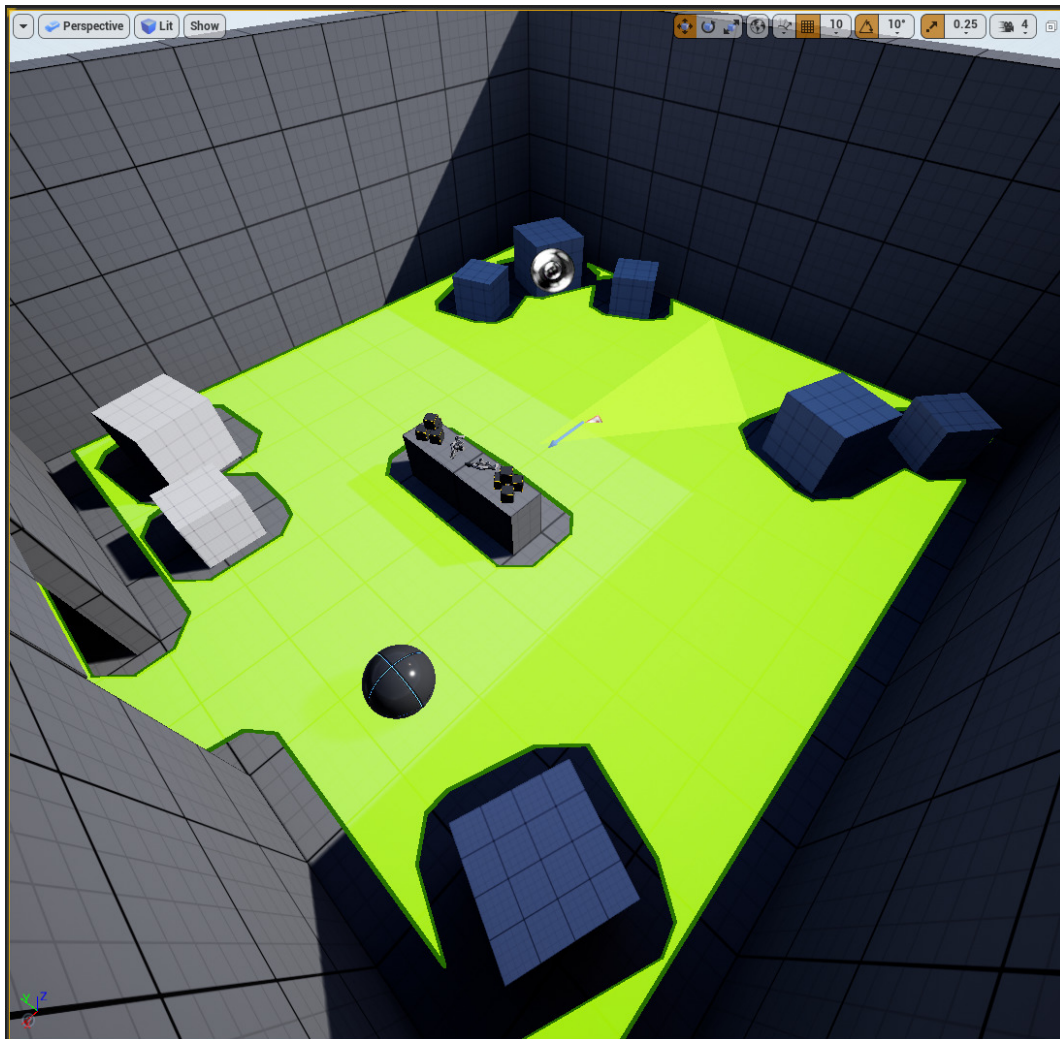
Figure 51: An example of a generated navigation mesh

9.1.6 Menu

The navigation menu allows users to customize the experience to their preferences. It opens when the menu button on the right Motion Controller is pressed. The menu has no advanced graphics and two simple functions: Mute and Quit. It is a simple UI Button Menu. The blueprint for this menu is called "Menu UI" and is located in Content > UI.

9.1.7 VR Spectator

Users can experience the museum without a VR headset with the VR Spectator. `VRSpectator` is located in Content > VRSpectator. To enable Spectator Mode in our application or Unreal Engine, press Tab to toggle from `VRGameMode` to `PCGameMode`. VR Spectator is incompatible with mobile VR devices, such as the Meta Quest.

Users can control the VR Spectator and view the user with the HMD in the virtual world with their mouse and keyboard using the following inputs detailed in Table 2.

Action	Input
Toggle VR Spectator	Tab
Move Forward	W
Move Backward	S
Move Left	A
Move Right	D
Move Up	Space
Move Down	Q
Turn	Mouse movement

Table 2: Input mapping for VR Spectator

9.1.8 Object Blueprint

There were two important parent blueprints for object interaction: `BP_GrippableObject` and `BP_TV`. These blueprints are stored in the Blueprint folder in Content Browser.

9.1.8.1 `BP_GrippableObject`

The technical logic behind this blueprint is explained in Section 5.2.1. `BP_GrippableObject` is an Actor Blueprint that inherits from `GrabbleInterface`. This blueprint is the parent blueprint for `BP_Instrument` and `BP_Furniture`.

To place an instrument that can play sound and is grabbable into the map:

- Drag the `BP_Instrument` into the map

- On the right panel, under Unreal Editors, click on Static Mesh

- Change the Static Mesh to the desired instrument mesh

- In General, change the soundwave to the corresponding sound cue of the instrument

To place grabbable furniture:

- Drag the `BP_Furniture` into the map
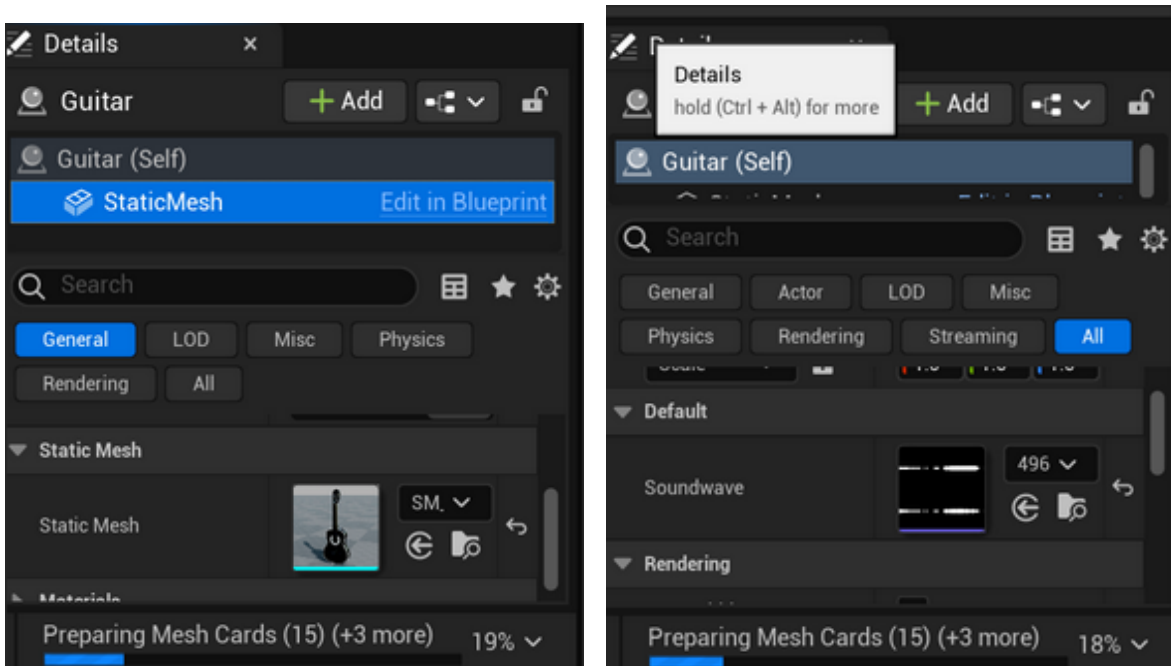
Figure 52: Configuration locations for `BP_Instrument`

- On the right panel, click on Static Mesh

- Change the Static Mesh to the desired furniture mesh

9.1.8.2 BP_TV

The technical logic behind BP_TV has been explained in Section 6.5. This blueprint is responsible for creating a TV that can play video and audio.

To place a screen with a video source:

- Import the video into the Movies folder

- Convert the imported media into a Media Player

- Insert the video into the Media Player

- From the Content Browser, create a media texture from the Media Player, then create a material from the texture

- From the Blueprints folder, drag the `BP_TV` into the environment

- In Unreal Editor, select Static Mesh under the Blueprint hierarchy

- Change the screen material to the created video material

- Under the hierarchy, change the sound source to the created media player.

Note: The static mesh can be changed to any media display mesh. However, ensure a separate material is assigned to the media display area of the mesh. Otherwise, this blueprint will not work.

48
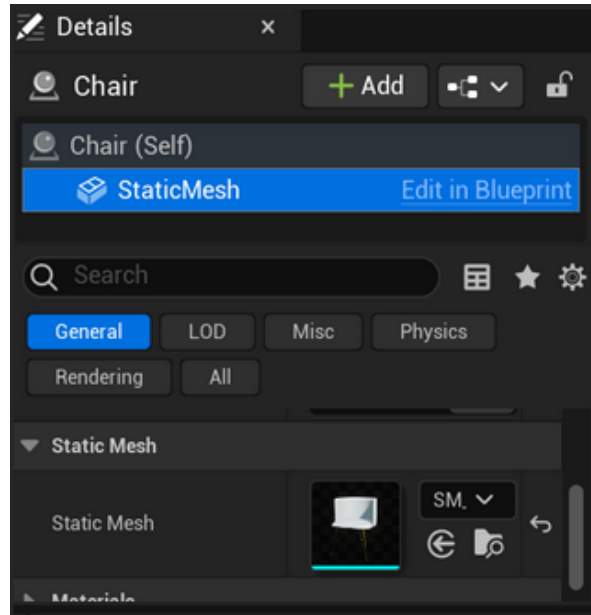
Figure 53: `BP_Furniture` details
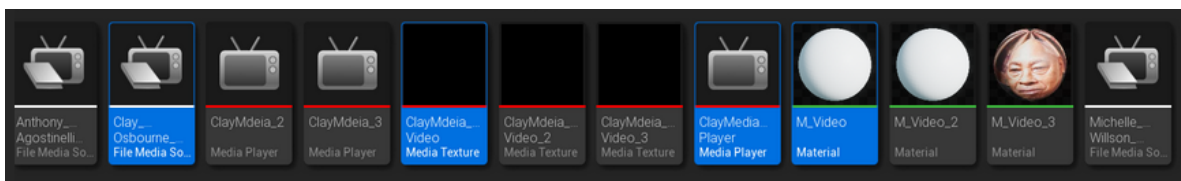
Figure 54: Components for creating a TV in the scene

49
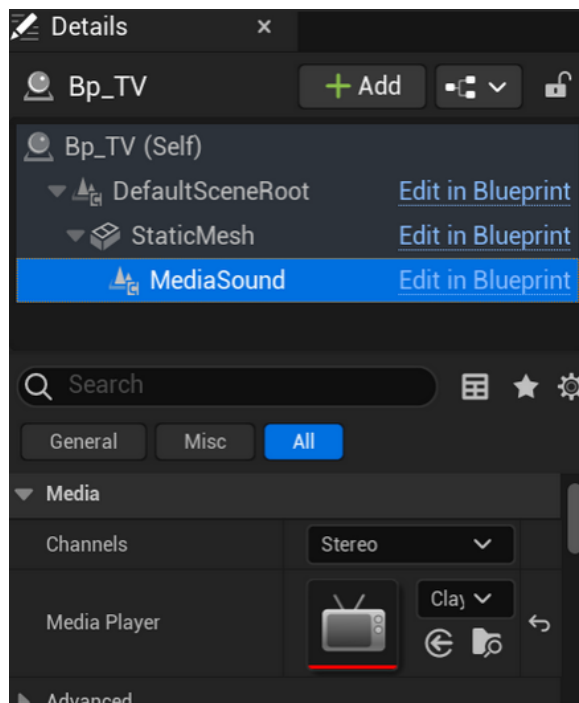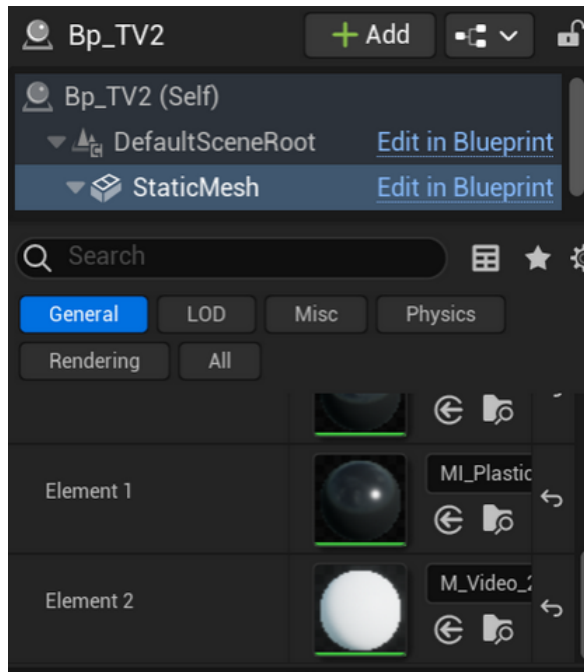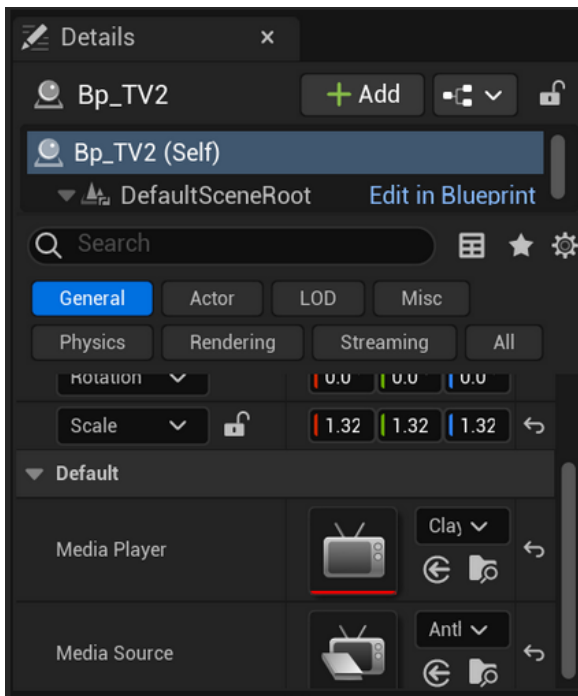
Figure 55: `TV_BP` details

UE Objects	Name of Object	Location	Description
Post Process Volume	`PostProcessVolume`	Place Actors panel > Volumes > PostProcessVolume	Using post-processing effects enables us to achieve the overall look and feel of the scenes. This feature affects the map's coloring, tone mapping, and lighting. More detailed settings of the post-process volume for each map are mentioned in Section 4.
Light Studio	`BP_LightStudio`	Content > Starter Content > Blueprints > `BP_LightStudio`	This is a blueprint created by Epic Games. It includes several lighting settings.
HDRi	`BP_LightStudio`	Content > Starter Content > Blueprints > `BP_LightStudio` > `HDRI`	A component within the LightStudio. HDRi is short for High Dynamic Range imaging, a type of texture that stores the lighting information from where the photo was taken. Using such data as a form of light in 3D sceneries is a highly effective method that improves our settings' natural and realistic appearance.
Light Sun & Atmosphere	`BP_LightStudio`	Content > Starter Content > Blueprints > `BP_LightStudio` > `Sun` and `Atmosphere`	Similar to the HDRi, this component stores lighting information. This feature is ticked in the Modern scene but off in the Jazz Club map.

Table 3: Effect components in the project

9.1.9 Maps

There were two main maps used for our project: `ModernMap` for the contemporary museum look and `Map_New` for the jazz club look. We suggest that if future teams want to work on these maps, they should make a copy. These maps included similar effects components to achieve their looks, listed in Table 3.

For static mesh, the general architecture layout can be achieved using all the static meshes in Content > Restaurant Content > Bases. Before adding the static meshes to the map, create a parent folder named "Base." Inside the Bases folder in the Restaurant Content, Ctrl+A and drag all the static meshes into the screen. These meshes are ready to use and already aligned with each other to create a contemporary space.

To add an object, click on the ground of the base and right click or shift+A to place a static mesh actor in. Alternatively, drag the object in from the content browser. For interactable objects, refer to the Object Blueprint section. The static meshes, textures, and materials used for this project are listed in the Table 4.

9.2 Recommendations for Future Teams

We chose these recommendations based on solid evidence from our data and project expertise. These suggestions will primarily benefit the JHDB and WPI in designing, developing, and expanding the

Figure 56: Figure base of the contemporary look

Figure 57: Twinmotion Musical Package

Artifact	Contents	Location	Description
Instruments	Static Mesh, Material, Blueprint for Instrument Alignment	Contents > Twinmotion Musical Packs	Twinmotion's Musical Pack 1 is a collection of 3D models related to musical instruments set up for use in Unreal Engine.
Restaurant Props	Static Mesh, Material, Blueprint	Content > Restaurant Content > Props	This collection included all the props to achieve a contemporary restaurant look.
JHDB Artifacts	Static Mesh, 2D Texture/Image, Media Players, Text Document	Content > MQP 2022-2023 Resources	This collection contained the content the JHDB had provided us. These contents were primarily used as posters, sounds effects, and video interactions.
Twinmotion Table & Chair Package	Static Mesh, Material, Blueprint	Contents > Twinmotion Table & Chair Packs	Twinmotion's Table & Chair Package is a collection of 3D models of tables and chairs. We used some meshes in this package to create variations in our design.
Twinmotion Materials for Unreal Engine	Material & Texture	Contents > Materials	This package contains extensive materials and textures from wood to bricks to concrete. We used this package to achieve different looks for the space.

Table 4: List of artifacts and locations in the project

project's current environment and interaction.

9.2.1 An opening scene or introduction map

We acknowledge the importance of an opening scene in any form of media. Without an impressive opening scene or introduction level, it is hard for audiences to retain their attention on the subject. The purpose of an opening scene for this project is first to grab the audience's attention on jazz, introduce all the functionality in the project, and set the tone for the entire project. Especially in games and a new experience like VR, where not everyone is familiar with the technology, an intro level or a tutorial would give the players the best feeling about the general art scene and how to interact with the whole experience.

9.2.2 A recording studio area in the project

We recommend that the future team create a recording studio as a new area for the museum to represent different perspectives of jazz. We tackled the performative side of jazz, and we think a new development on the production side of jazz would be an exciting idea for the audience, as sound is the project's gateway. The future team can show how musicians and artists produce jazz in the modern day and how to perverse an old recording. In addition, this room could double as a way to alter sound levels in the game. This would be particularly nice if the team could get access to the stems of a jazz recording. Then, it would be possible to create an area where the user could alter the volumes of specific instruments in a jazz piece while listening to it.

9.2.3 Implementing the narrative system

The narrative/guiding system is not fully implemented in the project's current version. This is because of a bug where the check for collision between the VR Character other collidable objects is failing. We believe the camera caused this as it seems to not be tracking the body capsule collision properly.

9.2.4 Approach the project from different angles

In discussion with our sponsor, Ben Young, we learned that one of the target goals of this project is to create an experience that users can bring home. A web-based experience can provide more accessibility to our target audience rather than limit it to an application-based VR experience. Many museums in the world moved their collection online via VR, allowing their users to access those contents conveniently without worrying about the size of the application.

9.2.5 Online meetings in the realm of VR

The JHDB hosts a weekly meeting on Thursday at 3 pm EST every week. We think having a function to attend the JHDB meeting via a meeting-like space in the virtual environment could be an exciting function to have.

9.2.6 IRB process

IRB is a lengthy process, especially for a VR-focused project. We recommend starting early and talking to someone from the IRB board to get the document right. For a VR project and the unique circumstances of the COVID-19 pandemic, the documents need to include research methodology, survey/interview questions, COVID-19 consent form, COVID-19 screening form, VR screening form, and the informed consent form.

Appendices

A Protofest Raw Survey Data

Below are the data collected from the Protofest survey.

Is there any experience that you would want to try in VR?

2 responses

> I wonder if these questions are mandatory or not, as I've never used VR, I left them blank.
>
> (This is Prof. Yarbrough)
>
> Anyways, feedback on your project is the same thing I ask always - What are the goals of the project and how do they match the goals of the end user as well as museums which may be interested in publishing/using this technology.
>
> It would be really beneficial to this project if you thought about crisp goals for the users - as far as engagement and effect. What would success look like for you? What would constitute failure?
>
> PS - I really really like header images on my google forms - takes two seconds and makes everything 10,000% more professional looking.

> i would always like more story with an immersive museum exhibit! I want to know why i should care, and a story is a great way to do that. Especially if the story is connected to the material in the exhibit.

On a scale from 1 to 5, what is your level of experience with Virtual Reality?

4 responses
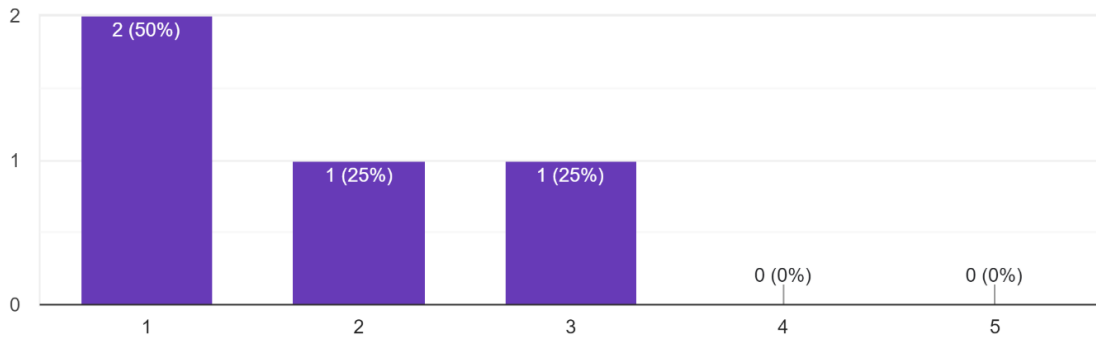
About how frequently do you use VR?
5 responses

- Never
- Less than once per month
- Once per month
- Once per week
- A few times per week
- Every day

40%

60%
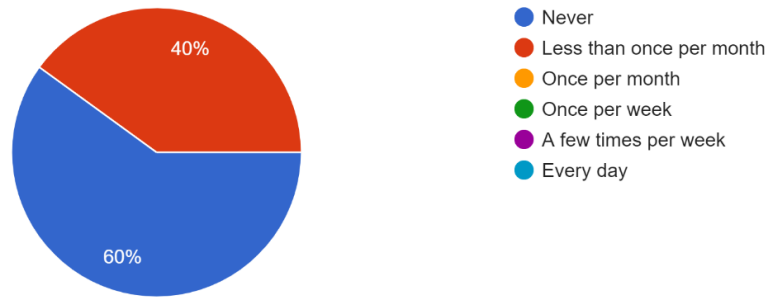
How long did it take for you to become comfortable with VR?
5 responses

- 1 hour
- 5 hour
- a day
- A week
- A month
- Longer
- I still feel uncomforatble with VR

80%

20%
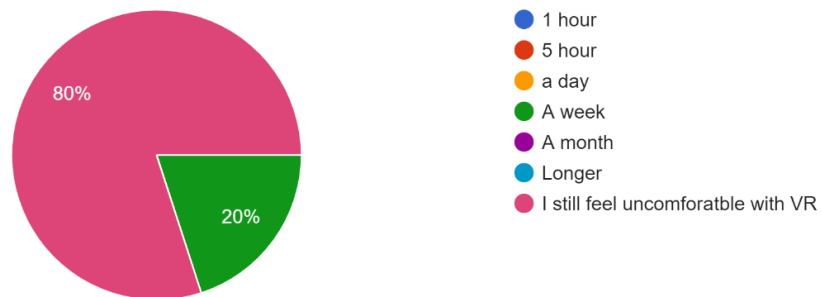
What is the ideal duration of an VR session? (ideal here means that you don't feel bored, nauseous, etc.)

3 responses

I have never used
20 min
about 5 minutes per section

If you have past experience with Virtual Reality, what accessories did you use?
4 responses

Monitor	0 (0%)
Keyboard/Mouse	0 (0%)
Joystick	1 (25%)
Haptic Glove(s)	0 (0%)
Headset(Oculus Quest, HTC Vive, Valve Index, etc.)	3 (75%)
Earphones with Microphone	2 (50%)
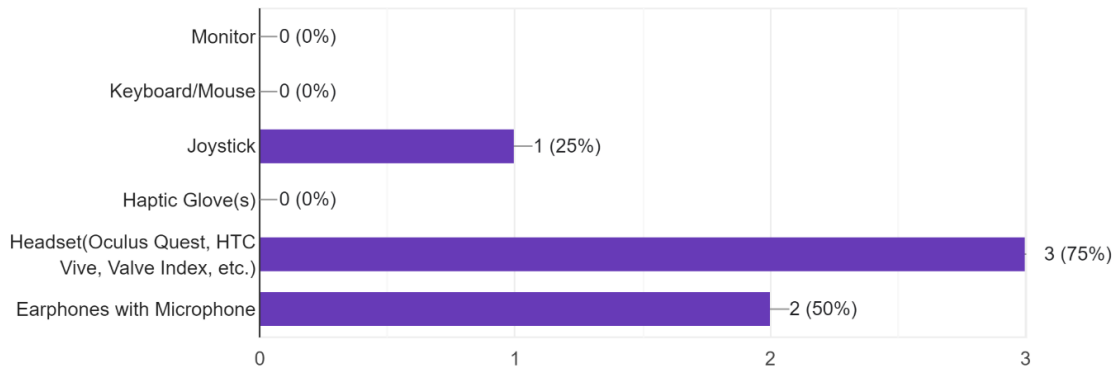
How immersed are you when you experience VR?
4 responses

1 — 1 (25%)
2 — 3 (75%)
3 — 0 (0%)
4 — 0 (0%)
5 — 0 (0%)
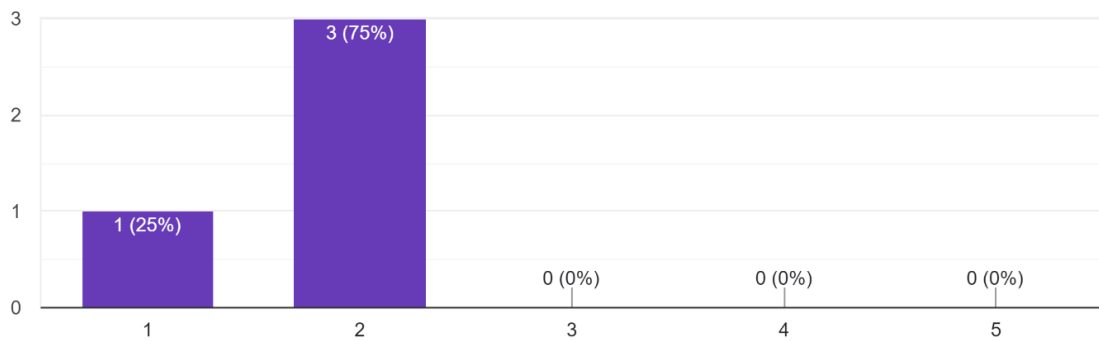
In your opinion, what are the most important components that distinguish VR from other platforms?
1 response

Immersive visuals	0 (0%)
Immersive audio	1 (100%)
The ability to move and manipulate objects	0 (0%)
Unique control scheme	0 (0%)

57
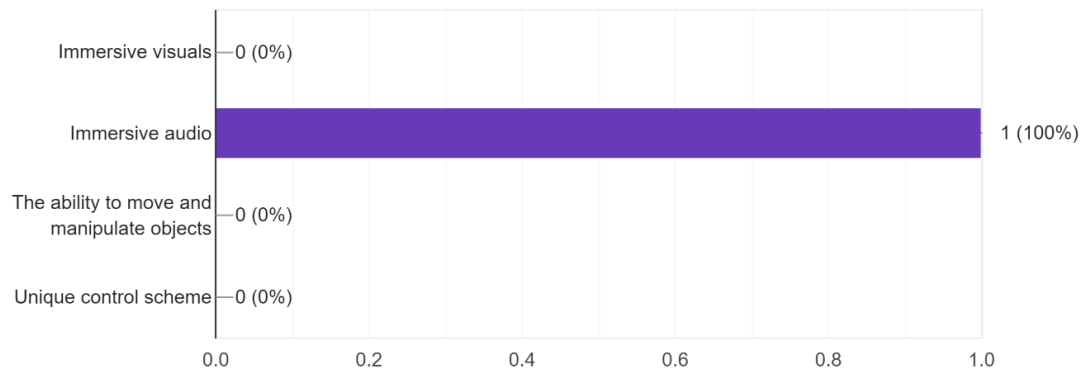
Did sound add to your experience?

4 responses

- Yes
- No
- Maybe

25%

75%
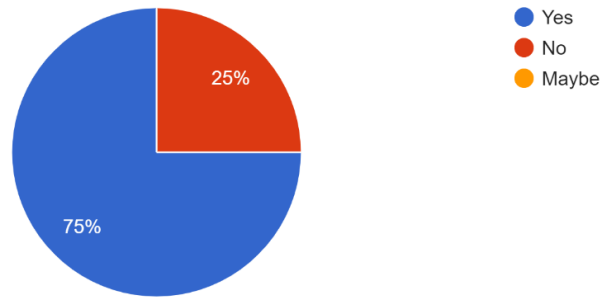
In your past experiences with VR, have you experienced any of the following?

1 response

Nausea — 1 (100%)

Eye pain — 0 (0%)

Disorientation — 0 (0%)

0.0   0.2   0.4   0.6   0.8   1.0
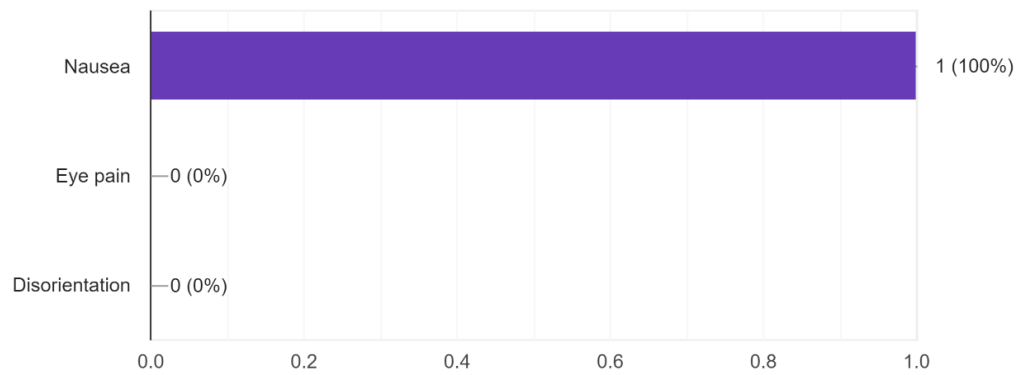
B   Alphafest Raw Survey Data

Below are the data collected from the Alphafest survey

Have you tried VR before?

8 responses

- Yes
- No
- Maybe

25%

75%
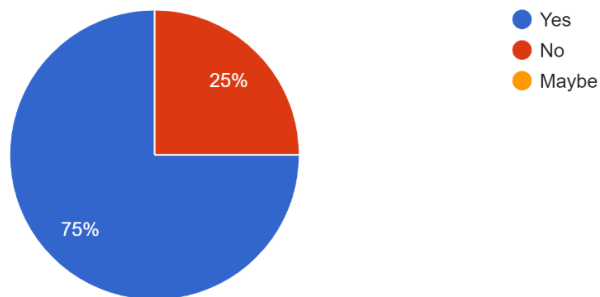
How comfortable are you with VR technology?
8 responses
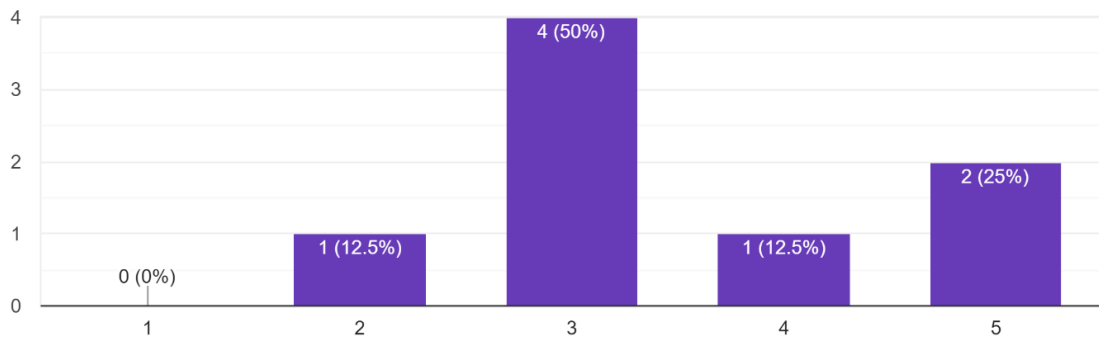
How difficult is it to navigate through the current level?
8 responses
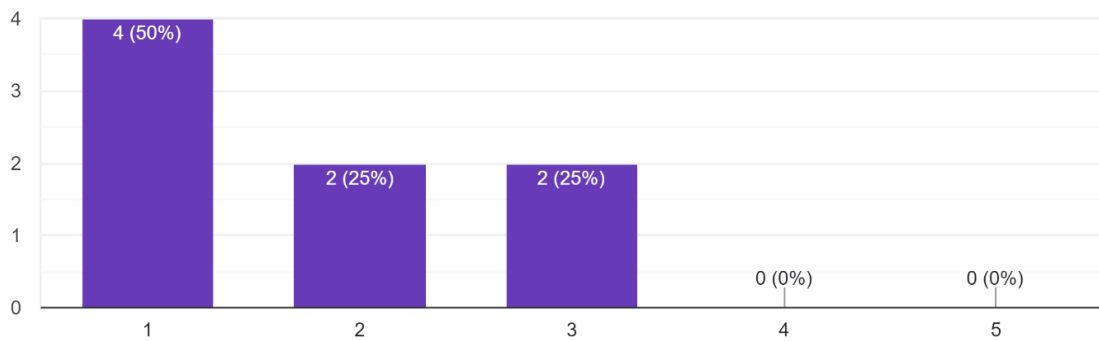
How difficult is it to use the teleportation ability?
8 responses
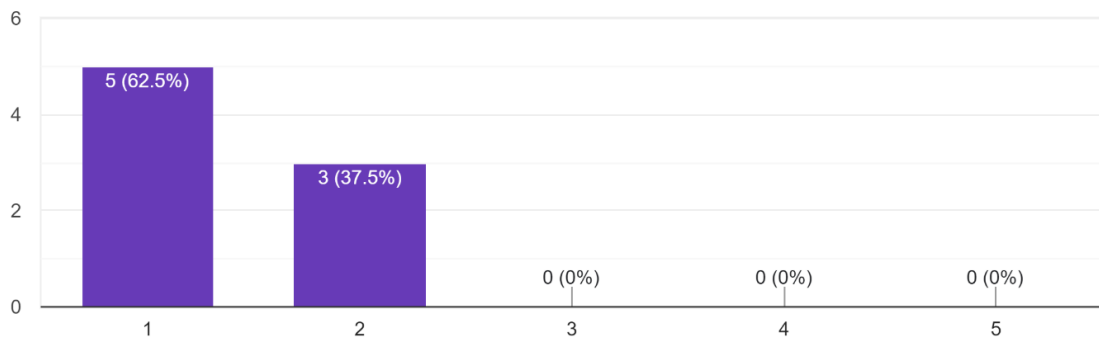
How do you feel about the Grab & Release function?
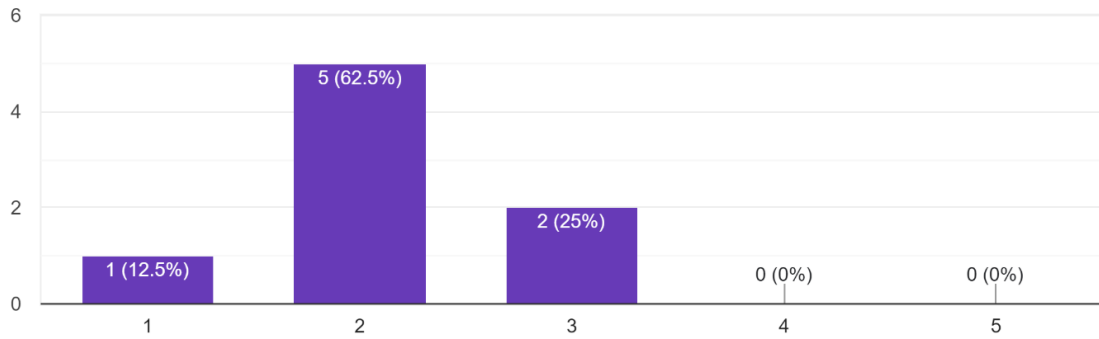
8 responses

What is your preference on Grabbing function?
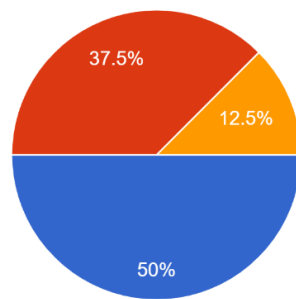
8 responses

- Remain as it is. Hold Grab to held the object
- Having the object stay on hold and only be released when press hold again.
- Remain as is, but I think you should let go of all objects when holding multiple at a time

We also have plan to include a dialogue system into this experience, do you think a dialogue system would enrich your experience?

8 responses
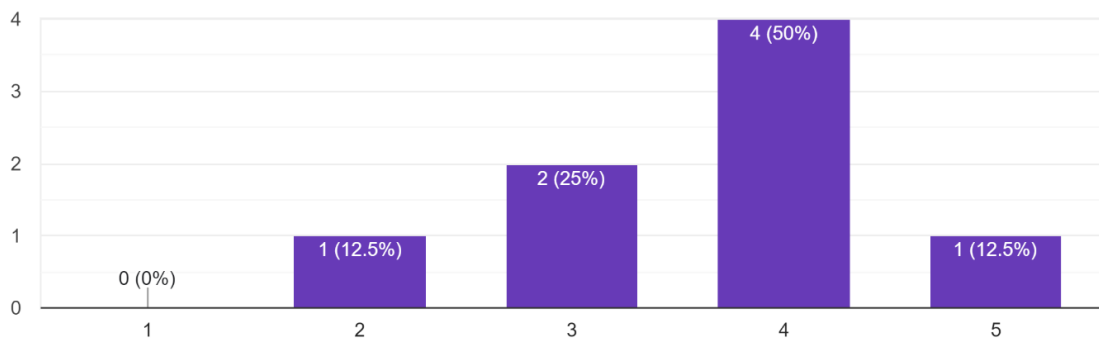
We also have plan to include a dialogue system into this experience, do you think a dialogue system would enrich your experience? And why?

8 responses

I think an optional dialogue system with also optional subtitles would be very helpful to the experience. It would help satisfy player curiosity about certain instruments or other objects.

I am not sure. Talking to NPC in a museum is weird

I just like to hear people explaining jazz things to me.

I don't know anything about jazz.

I believe that would be a perfect way to make this stand out from just going to a museum in person

I think interviews that play as you walk through the museum might feel a bit more natural to the experience.

It depends on how it is implemented - voice recognition is a lot and picking text options in VR is a little clunky. If the dialog feels one-sided, the player might feel like they're just being talked at, so tone and timing are important.

I think it would be similar to narration and add some flavor

With the dialog system, do you think being able to learn the story of one of the famous figure in jazz history would encourage you to learn more about jazz? Why?

6 responses

Yes, that would be a very interesting use of the dialogue system- if a funny story about its invention or an interesting story about a musician of its time, for example, is integrated into the game it would help spread knowledge and expand interest.

Definitely, I don't know much about jazz and would love to learn more!

YES! I think that being able to talk to the famous figures themselves would be perfect!

I don't know enough about jazz to say.

If it's a good story, I may feel compelled to research it further!

If i was interested in a certain figure yes

Was anything that struck to you as particularly unbalanced?

6 responses

It was a little weird that you can't put the instruments back because they pop off the stands once you pick them up, but not much else

no

No

Just walking a bit too fast but otherwise it was perfect

Moving objects from one hand to another.

The space is very open which is cool for movement, but it feels a bit empty. Jazz spaces are typically more cluttered/cozy feeling

What part do you say was the most fun to play with?

8 responses

The blocks were extremely fun to play with, stacking objects in VR is a very fun experience, and I think it could be expanded to the instruments(like the trumpets). The instruments being thrown very far is also extremely fun.

Really like the background music. Changing music while in different room might be a good idea.

Tossing instruments around

Throwing stuff

Being able to pick up the instruments and get a closer look at the models was really interesting!

Throwing stuff, but looking forward to more interaction with instruments!

Throwing trumpets!

Picking up instruments and exploring

We plan to introduce a narrative system in future integration. How do you feel about having a narrative system to guide you through the experience?

8 responses

I think that would be a fantastic experience, especially for those who aren't as used to games or prefer having the option available.

That will be great.

Do it!

I think that's a great idea

I feel like that would be a perfect addition to really nail the museum environment

Looking forward to hearing interviews as you explore the museum.

Narrative is cool :) Don't overscope yourself but voiceovers contribute to the experience if you have the means to fit it in

That would be great and make it feel like a guided tour through the museum

When you are exploring a destination, would you prefer exploring by yourself or having a guide during exploration?

8 responses

Explore by yourself — 3 (37.5%)

Having a guide during exploration — 5 (62.5%)

It depends on the destination and the vibe — 1 (12.5%)
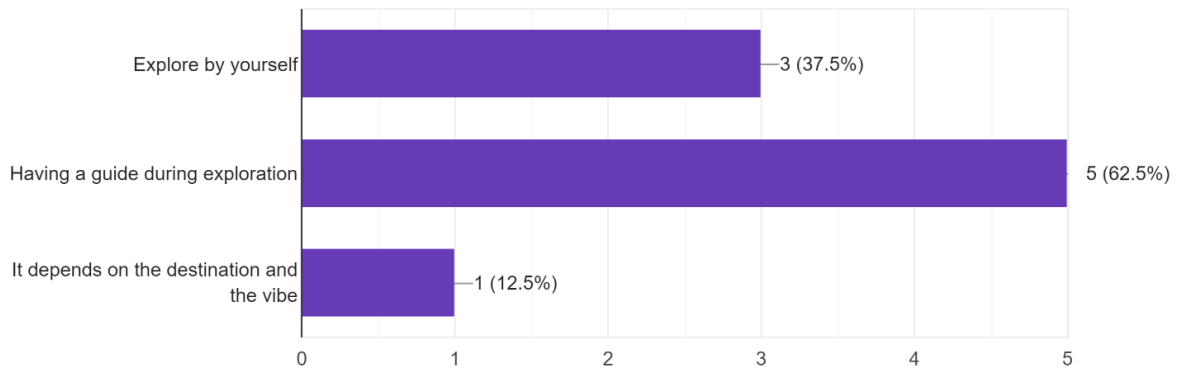
How do you feel about the locomotion? Did you face any difficulties while using it?

6 responses

It's very intuitive, no difficulties at all

No. Feel good with it.

No

I felt that it was a bit too fast when moving around but otherwise it was very smooth!

Locomotion might be a bit sensitive.

Touchpad motion is a bit fast, helpful for small adjustments but it can cause some motion sickness

How do you feel about the placement of the UI text at the beginning? Is it too high, too low, ...?

6 responses
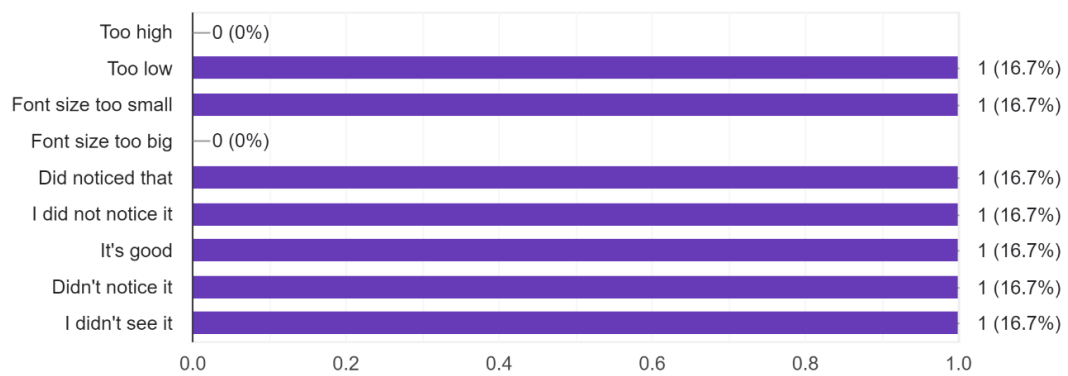
How important do you find these features from a VR accessibility standpoint?
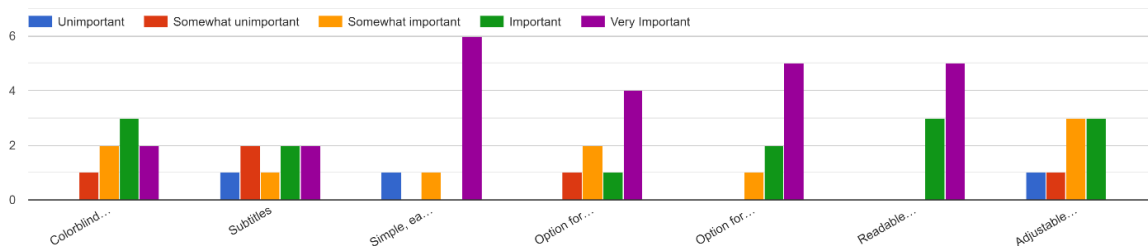
C Information in the IRB Application

Below is a copy of the information given in the IRB application required to do playtesting.

GENERAL INFORMATION

APPLICATION TYPE

Record #: IRB-23-0209

* What type of application are you submitting?
Exemption Application for student project involving minimal or no risk

* There are 3 application types available

Use this application for student projects involving interviews, surveys, focus groups, observation of public behavior or benign behavioral interventions, where there is minimal risk to research subjects. "Minimal risk" means that the risks to research subjects are no greater than those ordinarily encountered in daily life. Benign behavioral interventions include testing on-line games, websites and other behavioral studies that are brief, harmless, and could not be embarrassing or offensive. (This exemption is not appropriate for studies that involve survey/interviews of children. Please select the standard application.)

* Is this a student project?
☑ Yes ☐ No

* Student project type:
Undergraduate project (MQP, IQP, Suff., other)

* (Specify):
IMGD MQP

* Title of Study
Jazz History Database MQP

* Locations of Research: *(If at WPI, please indicate where on campus. If off campus, please give details of locations.)*
At WPI, mostly Fuller Lab and Unity Hall

Anticipated Dates of Research:

* Start Date:
11-Nov-2022

* Completion Date:
03-Mar-2022

* **Which of the following categories best describes your study?**
Social Sciences, management and other non-biomedical disciplines

* **Purpose of Study:**
(Please provide a concise statement of the background, nature and reasons for the proposed study. Insert below using non-technical language that can be understood by non-scientist members of the IRB.)
The purpose of this study is to learn more about users' behaviors and their interaction in VR settings.

* Has an IRB ever suspended or terminated a study of any investigator that will be listed on this protocol?
☐ Yes ☑ No

Please indicate if your study involves:

* Investigational drugs or investigational medical devices
☐ Yes ☑ No

* Hazardous Materials
☐ Yes ☑ No

* Special diets
☐ Yes ☑ No

* Collaborating Institutions: *(Please list all collaborating Institutions.)*
JHDB

* Investigational drugs or investigational medical devices
☐ Yes ☑ No

FUNDING INFORMATION

FUNDING INFORMATION

How will the study be funded?

☐ Grant/Contract/Subaward (Federal)

☐ Grant/Contract/Subaward (Non-Federal)

☐ Departmental funds

☐ Faculty start-up or incentive funds

☐ Investigator out-of-pocket

☑ No funding anticipated

STUDY PERSONNEL

Please list all study personnel below, and select a role for each. Use the check box on the left to indicate the principal investigator (PI). The PI must be a WPI faculty or staff member. Student applications that do not have a faculty/staff PI will be returned without review.

All study personnel having direct contact with participants must take and pass a training course on human subjects research. Upload copies of your training certificates where indicated below. Training is available at no cost to WPI-affiliated researchers through the CITI program.

Name
Sutter, Ralph

Primary Investigator   Involvement Start Date   Role
☑   16-Nov-2022   Faculty /
                                                                             Staff
                                                                             Investigator -
                                                                             WPI

Please upload a copy of your relevant HS training certificate(s):

Name
Nguyen, Thi Quynh Ha

Primary Investigator   Involvement Start Date   Role
☐   16-Nov-2022   Student
                                                                             Investigator

Please upload a copy of your relevant HS training certificate(s):

Name
Pelletier, Nicholas A

Primary Investigator   Involvement Start Date   Role
☐   16-Nov-2022   Student
                                                                             Investigator

Please upload a copy of your relevant HS training certificate(s):

DECEPTION

Record #:

Will your study involve deception of participants or incomplete disclosure of study details?

Deception means intentionally provide misleading or false information to participants.
Incomplete disclosure means withholding information from participants about the true purpose or nature of the research.

☐ Yes ☑ No

STUDY INFORMATION

* Expected Research Subjects:
(e.g. museum visitors under the age of 12)
   Staff and Students at WPI, Participants at Alphafest

* Project Mission Statement and Objectives:
   This project's goal is to warmly welcome those who might otherwise feel that the world of Jazz is somehow difficult to enter, or intimidating in some way. The virtual museum concept is yet another way to access the JHDB, the most important database of jazz music, history, and interviews from around the world.

* Brief Methods Listing:
(e.g. "Survey of public to ascertain knowledge and opinions about climate change" or "Interview of professionals working on climate change regarding effective city climate change program")
   Survey of participants to ascertain experience and knowledge about VR and Jazz

* Does the proposed research involve vulnerable research subjects?
(e.g. children, prisoners, students, persons with mental or physical disabilities)
   ☐ Yes ☑ No

* Does the research involve human subjects in ways <u>other than</u> as participants in interviews, focus groups, or surveys?
(e.g. observation of public behavior, use of archived data or experimental procedures)
   ☐ Yes ☑ No

* Will the researchers collect information that can be used to identify the subjects?
   ☐ Yes ☑ No

* Could the disclosure of a human subject's identity and responses place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability or reputation?
   ☐ Yes ☑ No

* Will the researchers disclose the identity <u>or</u> the individual responses of any human subjects?
(e.g. by quoting an individual, whether or not identified by name or title)
   ☐ Yes ☑ No

Appendix 1

Attach the statement of research methods or draft methodology chapter: [Research Methods](#)

Attach a draft of surveys and/or a list of questions to be used for interviews or focus groups: [Survey and/or Interview Questions](#)

If sample questions are included in Appendix 1, Methodology chapter, indicate the page numbers here:

ADDITIONAL DOCUMENTS

If you have any additional documents you would like to include with your application, you can upload them here.

Additional document:	[Consent Form](#)
Additional document:	[Covid Protocol](#)
Additional document:	[Covid Screening questionnaire](#)
Additional document:	[VR Screening Protocol](#)
Additional document:	[Users Recruitment Documents](#)

INVESTIGATOR'S ASSURANCE

All participants in this research project are agreeing to abide by the following instructions:

* ☑ You agree to inform subjects orally or in writing that:
- Participation in the research is voluntary.
- Participants may end their participation at any time.
- Participants need not answer every questions in an interview or suvey.

* ☑ If your research is **anonymous**, you also inform subjects that you are not collecting names or any identifying information from them.

* ☑ If your research is **confidential**, you inform subjects that no identifying information will be disclosed with individual responses.

* ☑ If your research is **NOT** completely anonymous and confidential, you must obtain each subject's permission to publicly disclose his or her identity and/or responses. All requests for anonymity and confidentiality must be honored. The subject must be offered the opportunity to pre-approve the publication of any quoted material.

* ☑ I certify that I have added all Study Personnel, including students, to the study personnel page.

Appendix 1

EForm Name: IRB Application
Page: Study Information
Section:
Question: Attach the statement of research methods or draft methodology chapter:
File Name: Research Methods

Methodology

To achieve our goal, we investigated the current challenges and users' feedback on the current prototype of the game/experience by doing a playtesting survey. The collected information helped us to determine the weakness and identified the direction for development for the overall experience.

The team then utilized survey, statical analysis to formulate recommendations for ourselves and the JHDB. The survey was distributed to users at WPI's DiGI events after playtesting our VR prototype.

Once playtesting section were completed, we analysed, compared our survey responses, and categorised the information we collected to different fit in features that we identified. The analysis helped us to draw a conclusion, provide a set of recommendations and better integrate the Jazz History Database Virtual Museum for future development.

Appendix 2

EForm Name: IRB Application
Page: Study Information
Section:
Question: Attach a draft of surveys and/or a list of questions to be used for interviews or focus groups:
File Name: Survey and/or Interview Questions

- Did you enjoy this VR experience?
- How difficult to navigate through this level?
- How is this experience separated from a normal experience at a museum?
- How much time did you feel like you were playing for?
- How emotionally invested in the game were you?
- What other games have you played that you feel are comparable and why?
- Did you have fun?
- What part would you say was the most fun? What would you recommend for the developers to improve this matter?
- What part would you say was the least fun? What would you recommend for the developers to improve this matter?
- Would you play the game again?
- Would you recommend the game to others?
- Was there anything that struck you as particularly unbalanced?
- Were there any rules or instructions that you felt were unclear?
- Were there any rules or instructions that hurt your enjoyment of the game?
- The timing in the game is designed at the normal level to feel like a cakewalk early on and move quickly to overwhelming towards the end. Do you feel this was conveyed accurately?
- Is there anything you feel needs to be added to this experience?
- If we have other questions, can we reach out to you from email?

<u>Appendix 3</u>

EForm Name: IRB Application
Page: Additional Documents
Section:
Question: Additional document:
File Name: Consent Form

Informed Consent Agreement for Participation in a Research Study

Investigator: Nguyen, Thi Quynh Ha; Pelletier, Niko Pelletier;

Contact Information: Nguyen, Thi Quynh Ha <tnguyen5@wpi.edu>; Pelletier, Niko < npelletier@wpi.edu>;

Title of Research Study: Jazz Database History Virtual Museum

Introduction:

      The Jazz History Database is an organization at WPI that stores different recordings of jazz history, including songs and interviews. Since jazz is not a popular genre of music anymore, most of its formats are outdated and difficult to preserve. Because of this, we decided to use a new, modern format to preserve these recordings: virtual reality. We created a 3D virtual environment where players could listen to jazz records and explore the history in the environment. We did this in hopes of bringing re-popularizing jazz music and its history.

PLEASE STOP USE OF THE VR EQUIPMENT IF YOU FEEL ANY DISCOMFORT WHATSOEVER.

Purpose of the study:
      This project's goal is to warmly welcome those who might otherwise feel that the world of Jazz is somehow difficult to enter, or intimidating in some way. The virtual museum concept is yet another way to access the JHDB, the most important database of jazz music, history, and interviews from around the world.

Procedures to be followed: When you enter the space, you will first be informed about the project and will be asked to if they want to try out the VR prototype. If you voluntarily to join the section, then the interviewer will provide the participants with the VR headsets. You would be presented with the choice to sit or to stand during the experience and be asked to put the VR headset on your head. The study investigator will give you a brief guide on how to use the system and direct you to do tasks, such us picking up an instrument or moving around the area. The section will last about 5-10 minutes (includes the setting time). After their experience, you will be asked to fill out a survey related to their experience. At any point, if you experience any feeling of discomfort, you can stop the procedures immediately.

Risks to study participants: Risks including nausea, motion sickness, dizziness, seizures, fear of heights, fear of bumping into objects, etc.

AT ANY POINT, IF YOU EXPERIENCE ANY OF THESE MENTIONED RISKS, PLEASE TALK TO YOUR INTERVIEWER AND YOU CAN STOP THE PROCEDURES IMMEDIATELY.

Benefits to research participants and others: The experience and knowledge in the VR space and Jazz database history

Record keeping and confidentiality: Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact: WPI Student Researchers: (Nguyen, Thi Quynh Ha <tnguyen5@wpi.edu>; Pelletier, Niko <npelletier@wpi.edu>;) The IRB Manager (Ruth McKeogh, Tel. 508 8316699, Email: irb@wpi.edu) and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu).

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below and agree to using the JHDB's Quest or VIVE headset, you are indicating your acceptance of the terms and conditions of this agreement. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

I wish to use the VR headset. I recognize and understand that the use of a VR headset involves certain risks.

1. I am using the VR equipment voluntarily.
2. I am informed with all of the physical, psychological, and financial risks associated with the use of VR equipment.
3. By signing this agreement, I acknowledge that I have read and understood all of the terms of this release form.

Date:
Study Participant Signature

_____
Study Participant Name (Please print)

_____   Date: _____
Signature of Person who explained this study

Appendix 4

EForm Name: IRB Application
Page: Additional Documents
Section:
Question: Additional document:
File Name: Covid Protocol

COVID-19 and Research Participation Consent Requirement

At WPI our primary responsibility related to research is to protect the safety of our research participants.

COVID-19 refers to the Coronavirus that is being spread across people in our communities. We need to provide you with important information about COVID-19, and to tell you about ways your participation might change because of COVID-19 related risk.

If you are considering joining a study at this time, **it is important that you consider the following information to determine if study participation is right for you at this time.**

How is COVID-19 spread?

COVID-19 is a respiratory virus spread by respiratory droplets, mainly from person-to-person. This can happen between people who are in close contact with one another (less than 6 feet). It is also possible that a person can get COVID-19 by touching a surface or object (such as a doorknob or counter surface) that has the virus on it, then touching their mouth, nose or eyes.

Can COVID-19 be prevented?

Current ways to minimize the risk of exposure to COVID-19 include "social distancing" which is a practice to decrease the potential for direct exposure to others who may have been exposed to COVID-19, for example by avoiding large gatherings or refraining from shaking hands with others. It is important to understand that since study participation may include increased travel outside of your home and increased exposure to others within a research site it may increase your exposure to COVID-19. At this time there is no vaccination to prevent COVID-19 infection.

What are the risks of COVID-19?

For most people, the new coronavirus causes only mild or moderate symptoms, such as fever and cough. For some, especially older adults and people with existing health problems, it can cause more severe illness, including pneumonia. While we are still learning about this virus, the information we have right now suggests that about 3 of 100   people who are infected might die from the virus.

Who is most at risk?

Individuals over 60 and with chronic conditions such as cancer, diabetes and lung disease have the highest rates of severe disease from the infection.

What do we do to minimize risk for research participants?

There are several ways we try to minimize your risk:

- If possible, we limit the number of times you have to come to a research site. If you choose to participate in our study, we limit to number of participations to 1.
- We ask every research participant if they have the symptoms of COVID-19 or have been in close contact with anyone who has or had COVID-19.
  - We will send you a form the day before and ask you if you have symptoms; we will also ask you at the beginning of the study visit.
- During your research visits, we try to reduce the time you are exposed to other people as much as possible.
  - You and only one investigator will be the only people in the lab.
- All areas where study subject visits will take place will have hospital-approved hand sanitizer available in the area.
- We are following the current clinical guidelines for cleaning rooms and equipment.
  - Ex: VR headset will be wiped and disinfected after each uses.
  The information related to risks of COVID-19 changes every day. The leaders at WPI are monitoring these risks and deciding how these risks should change our research. If you have questions about COVID-19 and your participation in research, please talk to the Jazz Database History Museum MQP team.

Appendix 5

EForm Name: IRB Application
Page: Additional Documents
Section:
Question: Additional document:
File Name: Covid Screening questionnaire

Covid Screening Questionnaire

This form is designed in an effort to reduce the risk of COVID-19 exposure and to protect the public, as well as our community at WPI, from the COVID-19 pandemic.

Participants will be asked to fill their name and contact email to proceed. Participants then be asked the Yes/No question for the Covid protocol.

1. I am not presenting any of the COVID-19 symptoms, such as fever, shortness of breath, dry cough, runny nose, sore throat.
2. I have not been in contact with a person who has been diagnosed with COVID-19 within the past 14 days.
3. Did you have a negative COVID-19 test result from a test taken 5 full days after your last exposure to the person who tested positive for COVID-19? (If it hasn't yet been 5 full days since your last exposure, select "YES").
4. I have not travelled outside the country within the past 14 days.

Appendix 6

EForm Name: IRB Application
Page: Additional Documents
Section:
Question: Additional document:
File Name: VR Screening Protocol

Screening process for use by WPI IRB investigators engaging subjects in Virtual Reality/Augmented Reality research studies.

The investigator should follow the prompts to exclude a participant in a Virtual Reality study if answer is [TERMINATE].

Screening take place before the research study to ensure participants are comfortable participating in the study.

Neither the participants' personal or health information will be kept if they are not selected to participate. The recruitment document will be shredded (destroyed) if the participant is not being selected for this study or decides not to answer specific categories of the questions (general health, vision/hearing condition and psychological & neurological health-related) embedded in this recruitment template.

*these sections are required for participation in the research

i. ***BASIC REQUIREMENTS**

Are you older than 18?
❏ Yes
❏ No **[TERMINATE]**

Are you comfortable with V.R. Equipment?
❏ Yes
❏ No **[TERMINATE]**

ii.   *GENERAL HEALTH REQUIREMENTS

If participant is not comfortable answering these questions, the recruitment process is terminated.

Do you feel dizzy right now?
- ❏ Yes **[TERMINATE]**
- ❏ No

Do you feel lightheaded right now?
- ❏ Yes **[TERMINATE]**
- ❏ No

Do you feel nauseas right now?
- ❏ Yes **[TERMINATE]**
- ❏ No

Do you feel excessively tired right now?
- ❏ Yes **[TERMINATE]**
- ❏ No

Do you feel sick right now?
- ❏ Yes **[TERMINATE]**
- ❏ No

Have you had more than what is usual for you, of caffeine or energy drinks today?
- ❏ Yes **[TERMINATE]**
- ❏ No

Have you had migraines, headaches, or earaches recently?
- ❏ Yes **[TERMINATE]**
- ❏ No

Do you have a history of low blood pressure or fainting?
- ❏ Yes **[TERMINATE]**

❏ No

Do you have a history of vertigo?
❏ Yes **[TERMINATE]**
❏ No

Are you currently pregnant?
❏ Yes **[TERMINATE]**
❏ No

> Question is biometrics specific.
> **Note that if subject is pregnant, they cannot participate as the unborn child can affect the biometric readings.**

iii. ***VISION & HEARING REQUIREMENTS**

If the participant is not comfortable answering these questions, the recruitment process is terminated.
❏ No, I do not want to answer these questions **[TERMINATE]**
❏ Yes, I do want to answer these questions

Have you ever used VR (Virtual Reality) or AR (Augmented Reality) before?
❏ Yes
❏ No

How often do you play video games? (on a monitor, phone, console etc.)
❏ Very frequently (Daily)
❏ Somewhat frequently (1-6 times per week)
❏ Occasionally (1+ times per month)
❏ Somewhat infrequently (2+ times per year)
❏ Very infrequently/Never (0-2 times a year)

Please select the option that best corresponds to your current state of vision.

❏ I have normal vision and do **not** require the assistance of glasses or contact lenses.

❏ I have normal-to-corrected vision for both eyes and require the assistance of glasses or contact lenses which I own.

❏ I have normal-to-corrected vision for one eye and require the assistance of glasses or contact lenses which I own.

❏ I am blind in one or both eyes. **[TERMINATE]**

> If subject says they have normal-to-corrected vision, please give reminder to bring glasses/contact lenses on the day of their scheduled appointment, otherwise they will not be able to participate.

Are you colorblind?
❏ Yes **[TERMINATE]**
❏ No

Hearing- Please select the option that best corresponds to your current state of hearing.
❏ I have normal hearing and do **not** require the assistance of hearing aids or other hearing devices.

❏ I have normal-to-corrected hearing for both ears and require the assistance of hearing aids or other hearing devices which I own.

❏ I have normal-to-corrected hearing for one ear and require the assistance of hearing aids or other hearing devices which I own.

❏ I am hard of hearing. **[TERMINATE]**

> If subject says they have normal-to-corrected hearing, please give reminder to bring assisted hearing devices on the day of their scheduled appointment, otherwise they will not be able to participate.

Are you highly prone to motion sickness? (From travel, heights, roller coasters etc.)
❏ Yes **[TERMINATE]**

❏ No

❏ Not sure **[Give disclaimer to subject that they will be in VR for X minutes, and it is their discretion whether they are comfortable participating.]**

iv.   ***NEUROLOGICAL & PSYCHIATRIC REQUIREMENTS**

If you the participant is not comfortable answering these questions, the recruitment process is terminated.

❏ No, I do not want to answer these questions **[TERMINATE]**

❏ Yes, I do want to answer these questions

Have you ever had a brain injury that resulted in memory loss or unconsciousness?

❏ Yes **[TERMINATE]**

❏ No

Are you currently diagnosed with any of the following? Please select all that apply.

❏ Autism **[TERMINATE]**

❏ Bipolar disorder [**TERMINATE]**

❏ Cerebral Palsy **[TERMINATE]**

❏ Encephalitis (inflammation of the brain) **[TERMINATE]**

❏ Epilepsy **[TERMINATE]**

❏ Intellectual disability [**TERMINATE]**

❏ Major depression [**TERMINATE]**

❏ Muscular dystrophy **[TERMINATE]**

❏ Obsessive-compulsive disorder (OCD) [**TERMINATE]**

❏ Post-traumatic stress disorder (PTSD) **[TERMINATE]**

❏ Schizophrenia [**TERMINATE]**

❏ I would prefer not to answer **[TERMINATE]**

❏ Other **[Please have subject describe and consult with Neurable to see if subject is applicable]**

❏ I am not not diagnosed with any of the following. **[Move onto next question]**

Are you taking any of the following medications?

- ❏ Antidepressants (e.g. Prozac, Cymbalta, Nardil) **[TERMINATE]**
- ❏ Antipsychotics (e.g. Thorazine, Abilify) **[TERMINATE]**
- ❏ Anxiolytics (e.g. Xanax, Lunesta, Ambien) **[TERMINATE]**
- ❏ Mood stabilizers (e.g. Tegretol, Gabapentin) **[TERMINATE]**
- ❏ Stimulants (e.g. Ritalin, Adderall) **[TERMINATE]**
- ❏ I would prefer not to answer **[TERMINATE]**
- ❏ Other **[TERMINATE]**
- ❏ I am not taking any of the medications. **[Proceed]**

Appendix 7

EForm Name: IRB Application
Page: Additional Documents
Section:
Question: Additional document:
File Name: Users Recruitment Documents

Hi,

Our team has been working on a new research study in VR and we need your help.

Our goal of this new study is to warmly welcome those who might otherwise feel that the world of Jazz is somehow difficult to enter or intimidating in some way.

The Jazz History Database is an organization at WPI that stores different recordings of jazz history, including songs and interviews. Since jazz is not a popular genre of music anymore, most of its formats are outdated and difficult to preserve. Because of this, we decided to use a new, modern format to preserve these recordings: virtual reality. We created a 3D virtual environment where players could listen to jazz records and explore the history in the environment. We did this in hopes of bringing re-popularizing jazz music and its history.

The playtesting session will place in Innovation Studio and run about 10 – 15 minutes each including the experience and filling the surveys. Play testers will be asked to fill out an informed consent and screening form before playing. Once you've played, you will then answer a survey based on your experience. We will also be giving out playtesting credit to those who need it.

Who Can Participate?

- Over 18 years old.
- Those who are comfortable with VR equipment.
- Those who are NOT highly prone to motion sickness.

If you fit these requirements and are interested in helping, sign up for the study here.

Thank you,

Jazz History Database MQP Team

References

Benjamin Moore & Co. (2020). *Using warm & cool paint colors.* https://www.benjaminmoore.com/en-us/color-overview/color-insights/warm-and-cool-colors

Berkman, M. I., & Akan, E. (2019). Presence and immersion in virtual reality. In N. Lee (Ed.), *Encyclopedia of computer graphics and games* (pp. 1–10). Springer International Publishing. https://doi.org/10.1007/978-3-319-08234-9_162-1

Bond, J. G. (2018). *Introduction to game design, prototyping, and development: From concept to playable game with unity and c#* (2nd). Addison-Wesley.

Bos, D., Miller, S., & Bull, E. (2022). Using virtual reality (vr) for teaching and learning in geography: Fieldwork, analytical skills, and employability. *Journal of Geography in Higher Education*, *46*(3), 479–488. https://doi.org/10.1080/03098265.2021.1901867

Cook, R. (2012). Miles Davis: 'Coltrane was a very greedy man. Bird was, too. He was a big hog' – a classic interview from the vaults. *The Guardian.* https://www.theguardian.com/music/2012/nov/06/miles-davis-interview-rocks-backpages

De Novo Agency. (2023). *Marketing for jazz musicians: All you should know in 2023.* https://denovoagency.com/blogs/music-industry/marketing-for-jazz-musicians-all-you-should-know

Epic Games. (n.d.). *Unreal engine 5.1 is now available.* https://www.epicgames.com/site/en-US/news/unreal-engine-5-1-is-now-available

Fish, N., & Higgins, A. (2022). *Jazz history database virtual museum* (tech. rep.). Worcester Polytechnic Institute.

Hall, S. (2017). *The painful birth of blues and jazz.* https://blogs.loc.gov/folklife/2017/02/birth-of-blues-and-jazz/

Jazz Club Étoile. (2023). *Home.* https://www.jazzclubetoile.com/

Langbehn, E., Lubos, P., Bruder, G., & Steinicke, F. (2017). Bending the curve: Sensitivity to bending of curved paths and application in room-scale vr. *IEEE Transactions on Visualization and Computer Graphics*, *PP.* https://doi.org/10.1109/TVCG.2017.2657220

Langbehn, E., Lubos, P., & Steinicke, F. (2018). Evaluation of locomotion techniques for room-scale vr: Joystick, teleportation, and redirected walking. *Proceedings of the Virtual Reality International Conference - Laval Virtual.* https://doi.org/10.1145/3234253.3234291

Lee, K. G. (2023). *The balancing act of assumptions & facts in ux.* https://uxplanet.org/the-balancing-act-of-assumptions-facts-in-ux-65124b818d98

MasterClass. (2021). *What is jazz? a guide to the history and sound of jazz.* https://www.masterclass.com/articles/what-is-jazz

Matticoli, M., & Varella, L. (2020). *Jazz history database global contributor project* (tech. rep.). Worcester Polytechnic Institute. 100 Institute Road, Worcester MA 01609-2280 USA.

Rogers, E. (2020). *Big band arranging: 2: Getting started.* https://www.evanrogersmusic.com/blog-contents/big-band-arranging/getting-started

Schuller, G. (2023). *Jazz.* https://www.britannica.com/art/jazz

Smithsonian American Art Museum. (n.d.). *Beyond the walls: Experience the smithsonian american art museum in virtual reality.* https://americanart.si.edu/beyond-the-walls

Sullivan, D. (2022). *These 10 beige hues add personality and character to a room.* https://www.thespruce.com/best-beige-paint-colors-4588138

Tanirgan, E. (2018). *Whiplash - drum cover in vr (paradiddle).* YouTube. https://www.youtube.com/watch?v=cZKheiV1n4c

The National Museum of Finland. (n.d.). *Watch and listen.* https://www.kansallismuseo.fi/en/open-museum/watch-and-listen