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Metaverse-Enhanced Virtual Reality Using Avatar for University Campus

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Abstract

With Metaverses and Virtual reality in its initial ages and even in its initial ages it is doing wonders for humanity. One of the most important things it contributes to is in education. This thesis explores the possibility to get to know how Metaverse-Education University Campus, with the main focus of avatar-based orientation programs in VR environment. This study focuses on how effective this technology is alongside how it can improve the educational possibilities. We applied many methods to this approach; we used ureal engine 4 to make the 3d Virtual Environment for the VR orientation session. Unreal Engine was again used to create Avatars and the VR capabilities. The findings are expected to provide insights into the benefits and challenges of implementing VR-based orientation programs and offer recommendations for educational institutions considering adopting Metaverse technologies. This study contributes to the literature on educational technologies in the world already published and gives

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a platform to institutions such as universities and colleges to provide a starting blueprint to implement VR-based education into their campuses.

Keywords: VR, Avatars, educational technologies, Metaverse

Introduction

During the COVID-19 Pandemic the entire world was in lockdown, due to which many day-to-day basic routine tasks were halted. We saw students unable to go to schools, workers unable to get to offices and in general we saw many of our day-to-day tasks being seizing to exist. But life must go on and such hurdles like the COVID-19 Pandemic should be combated and overcome. Keeping this in mind, if in the near future we face something like this again it will surely disrupt our modes of life . In order to tackle such a situation with respect to education this research focuses on ways that we can combat such a situation in which Face to face education is not possible. The use of technology and the internet must be used for the education of the masses. Our research focuses on using VR technology to create realistic settings to export over the internet for the education of the masses.

Problem Statement

Not every student has the opportunity to attend university physically. This may be possible due to a number of reasons such as riots, protests, extreme weather, transit blockade, lockdown and many more. Usually, such situations do not settle quickly and take a good chunk of time to be resolved.

The time lost could have been used in much better and productive activities such as sports, education etc. We must solve this problem by providing a solution such that this time is not all in vain. We will solve the educational aspect of it by using software

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like Unreal Engine4 and Technologies like VR to create a solution for the continuation of education.

Literature Review

Metaverse and virtual reality (VR) technologies combined have created many exciting possibilities for the future of education. The combination of these technologies contains the potential for drastically improving many aspects of education regarding how students engage with the learning material, the orientation process, the campus experience and much more. Problems like the COVID-19 Pandemic are just one of the many issues we face, which restrict our movements, but life must go on and in order for its smooth functioning we must use technologies present to remain resilient and move forward during these turbulent times

The rapid evolution of the Metaverse and Virtual Reality (VR) technologies is creating new possibilities in educational settings. These technologies provide an immersive, interactive environment where students can engage in learning experiences beyond the constraints of traditional classroom environments. This literature review examines the current state of research on the integration of Metaverse and VR technologies in education, focusing on their application in university campuses and avatar-based orientation programs, as well as the comparative advantages of game engines such as Unreal Engine 4 and Unity in creating VR environments. This literature review will try to explore the pre-existing research and academic literature available on how the metaverse alongside VR can enhance the university campus experience through avatar-based orientation/ interactive sessions.

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The Metaverse and Education

The Metaverse is a massive collection of virtual reality, which combines/bends virtually enhanced physical reality and the persistent spaces in virtual reality. The two technologies used in the Metaverse are Virtual reality (VR) and Augmented reality (AR). Virtual reality is a simulation experience that employs 3D near-eye displays and pose tracking to give the user an immersive feel of a virtual world. Whereas Augmented reality (AR) is an interactive experience that combines the real world and computer-generated 3D content which is heavily virtual reality-like. As described by Mystakidis (2022), the Metaverse is a significant evolution in interactions in the digital sphere, they offer a more immersive experiences than a traditional screen-based methods of learning like from a laptop, phone etc. Also, in the research done by Johnson et al., (2022), the educational applications of the metaverse are many, providing opportunities for making more interactive, immersive and a very personalized learning experience in a personalized environment Göçen (2022) examined the Metaverse's role in education and highlighted its ability to extend learning beyond physical classrooms, creating environments where students can interact in real-time, conduct virtual experiments, and simulate real-world scenarios.

Virtual Reality in Educational Settings

Virtual Reality is in the stage where its educational benefits are being explored continuously. VR offers a more immersive experience, interactive setting and a near identical physics-based movement in a 3D copy of a physical environment this makes many complex tasks and complex concepts be more accessible and engaging of the user.

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In the research Radianti et al. (2020) , it was found that VR can enhance outcomes of various problems by providing a more hands on experience, rather than seeing something on a screen and interacting with a mouse, in VR you can see the manifestation of that object in a similar 3D space, largely increasing the ease of learning ,very drastically decreasing the steep learning curve in most problems.

Again, the effectiveness of VR has been demonstrated across many fields like medical training, engineering in the research paper by (Bailson, 2018).

Virtual reality can also recreate existing physical settings , so that VR users can experience it , like recreating heritage sites that can be preserved in a digital environment so that when even they do not exist in physically, we know what they looked like. (Mahardika, M. S., & Junaidy, D. W. ,2023).

Moreover, Freina and Ott (2015) emphasized that VR provides significant pedagogical advantages, such as increased motivation, engagement, and the ability to simulate complex environments, making learning more accessible and intuitive. For instance, VR-based simulations in medical education have been shown to enhance students' skills by providing safe, controlled environments for practice (Hussein & Nätterdal, 2015).

Avatar-Based Orientation Programs

Universities programs like orientation, classes and events are crucial aspects of the learning curve that help students better adapt to the campus life offered. Traditionally, these programs take place on campus like on campus tours, lectures, informational sessions and social events etc. However, this can sometimes be logistically challenging as not all students will be able to reach the

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venues at time. At times like the pandemic such events get cancelled. And students may not engage effectively with one another.

In a study by Lee et al. (2021), avatar-based VR orientations were shown to increase student engagement, offer flexible access to orientation resources, and enhance social interactions.

Each student has his own mind, way of thinking likes and dislikes, keeping this in mind users try to customize their avatars and other personal profile info indicators. The use of avatars allows students to personalize their virtual presence and interact with peers and faculty in a meaningful way (Kozlov & Johansen, 2020). Kumar and Smith (2023) investigated the role of avatars in VR classrooms, concluding that they enhance student engagement by providing a more interactive and personalized experience. Additionally, Lee (2023) explored the use of avatars in virtual university programs and found that they significantly improved collaboration, allowing students to engage with peers and faculty in more meaningful ways, compared to traditional online platforms.

Challenges and Considerations

The Benefits of Metaverse and VR technology are massive and profound. They have massive significance yet at the same time they pose many challenges to consider before use. The technical issues include the hardware requirements and the software compatibilities. Both of which cause hindrance to the implementation.

Accessibility and inclusivity are also concerns, as not all students may have access to VR technology or feel comfortable using it (De Freitas & Veletsianos, 2010)

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Privacy and security are critical, as the use of avatars and virtual spaces can raise data protection and online safety issues (Bailenson, 2018).

Unreal Engine 4 Vs Unity For Vr Development

A crucial aspect of developing VR environments is selecting the appropriate game engine. Two of the most prominent engines used for VR development are Unreal Engine 4 (UE4) and Unity. While both engines have been widely adopted in the gaming and VR industry, recent research suggests that Unreal Engine 4 offers several advantages, particularly in terms of visual fidelity and ease of use.

Smith and Doe (2023) conducted a comparative study of UE4 and Unity and found that UE4's advanced rendering capabilities provide more photorealistic environments, which are essential for creating immersive VR settings. This is particularly important in educational settings, where high realism enhances the learning experience. The use of blueprints in UE4, a visual scripting tool, further simplifies the development process, allowing developers to quickly create and iterate complex environments without extensive programming knowledge (McMenamin, 2018). The study also highlighted that UE4's physics engine and built-in support for realistic locomotion make it more suitable for VR applications that require detailed interactions and movement, such as virtual classrooms and university campuses. Chang et al. (2022) explored the development of a VR campus tour application using UE4 and reported that it significantly improved users' understanding of the campus layout and facilities compared to a traditional tour. The visual accuracy and immersive nature of the VR environment created with UE4 led to higher user engagement and satisfaction.

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case studies and empirical research

There are various studies on the use of metaverse, the use of VR technology in university settings alongside outside the university as well.

For instance, Chang et al. (2022) investigated a VR campus tour application for prospective students, finding that it significantly improved their understanding of the campus layout and facilities

Also, Alpala and Quiroga-Parra (2022) demonstrated the use of UE4 to develop VR-based smart factory simulations for engineering students. Their research showed that students who participated in VR-based learning environments had improved engagement and better retention of complex concepts compared to those in traditional classroom settings.

Another study by Huang et al. (2021) examined VR-based lab simulations' impact on engineering students which is reporting positive outcomes in terms of knowledge retention and skill development.

Global Adoption Trends

The global adoption of VR technologies in higher education has seen significant growth over the past few years. A prime example is Stanford University, which implemented a virtual campus tour for new students using the Stanford Virtual Human Interaction Lab (VHIL). This immersive experience allowed students to navigate the university's campus without physically being there, offering a real-time interaction with faculty and other students through customized avatars.

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In another case, Harvard University utilized VR for its medical students, providing them with a simulated operating room where they could practice surgical techniques in real-time without the risks associated with actual patients. Such applications demonstrate the transformative power of VR in creating accessible, interactive educational experiences that traditional methods cannot match.

These implementations offer a glimpse into the future of education, where virtual reality and Metaverse platforms will become standard practice, allowing universities to reach broader audiences while maintaining the high levels of engagement seen in physical classrooms.

Emergeing Technologies and Technological Evolution

As we move further into the fourth industrial revolution, the landscape of education is undergoing rapid transformation. The convergence of AI, Metaverse, and Virtual Reality will soon enable AI-powered avatars to assist in personalized education, guiding students through virtual classes and labs. With haptic feedback technology becoming more advanced, the potential for immersive experiences where students can physically feel interactions is on the horizon. This not only heightens engagement but also enables tactile learning in fields such as medical sciences, where students can practice surgeries in a simulated environment, or engineering, where they can interact with virtual machinery.

In terms of hardware, we anticipate significant strides in the development of virtual reality headsets. For instance, Apple's upcoming Vision Pro promises to deliver unmatched visual clarity and comfort, pushing the boundaries of immersive learning even further. As these technologies evolve, the Metaverse will become

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increasingly seamless, blurring the lines between physical and virtual worlds in educational settings.

Methodology

Research Design

Our research design was basically to create a basic virtual reality Metaverse based university campus, lets break this down into basic pieces:

1. Metaverse
2. Virtual Reality
3. Avatar
4. University Campus

Metaverse

To understand the term metaverse, we must first know about multiverse which is a concept in quantum physics that there are an infinite number of parallel universes in the grand scheme of things. The word "Meta" is the new name of Facebook, Facebook created the Metaverse as an online VR platform that was made readily available for everyone and thus the name metaverse.

The idea of Metaverse is not a new one. The idea of many individuals existing in parallel in a virtual 3D space is very common , it was first ushered back in 1992 science fiction novel Snow Cash, where the two words "meta" and "universe" were used. Metaverse is heavily integrated into many software's and their communities such as VR chat, Roblox and the Sandbox just to name a few.

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Figure.1: Metaverse Concept

Virtual Reality

Virtual reality, also abbreviated as VR, is a simulation experience that employs 3D near-eye displays and pose tracking to give the user an immersive feel of a virtual world. In VR, a digital render of the physical world is made, then the user is also rendered, and the necessary physics of the user's movement is translated into the digital world. Essentially a digital copy of the user's existence and movement is made and replicated in a virtual environment that exists only as 0's and 1's.

Figure.2: Virtual Reality Concept Photo

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Avatar

An Avatar is mainly a virtual representation of the user. It will be the digital twin of the user, a character in the virtual world that will do work digitally on behalf of the user. An avatar is simply an icon of a person in space. It represents them and is used to identify them. we used the unreal engine 4's blueprint pack of "Advanced locomotion system". It provided use with an avatar of a third person character with locomotion and basic physics built in.

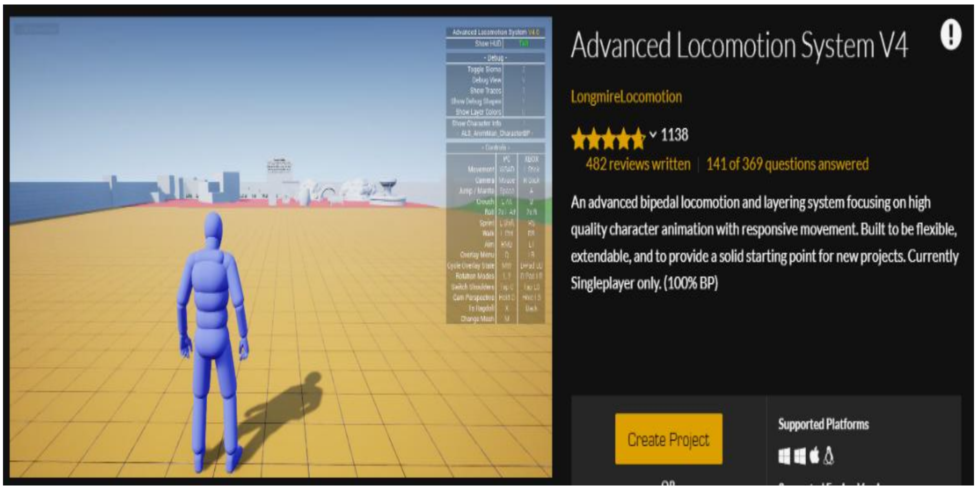

Figure.3: The Advanced Locomotion System in the Unreal Marketplace

Figure 3 shows the Advanced Locomotion System V4 on the Unreal Engine Marketplace. It is a very comprehensive full character pack containing multiple animations that are joined together via the advanced locomotion system implemented in it. This locomotion seamlessly transitions animation leading to very realistic and human-like movement in the game or research that it is being used. On top of this, eh physics settings in this character pack is much more advanced and realistic which means that the physics experienced by the user will be nearly identical to real life physics. That is the main reason this asset was used to be the as

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model for the avatars that will be accessed by the users in VR of the Third Person perspective.

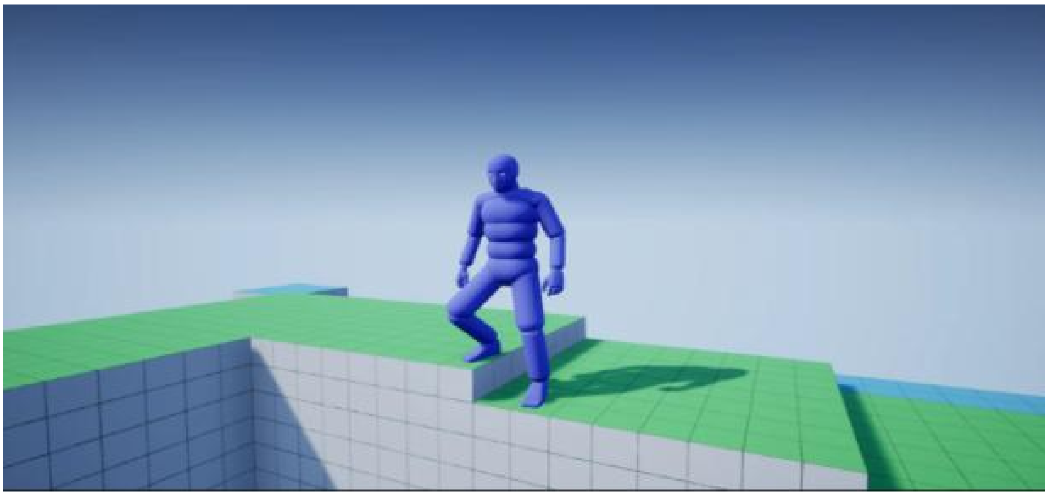

Figure.4: The Advanced Locomotion displaying Basic Locomotion and Physics

Advanced locomotion has been tested and used in multiple video games as well. This only adds to the fact that is a very reliable starting point that can benefit use by using it in this research. It takes care of the basic movement and the gravity system for us.

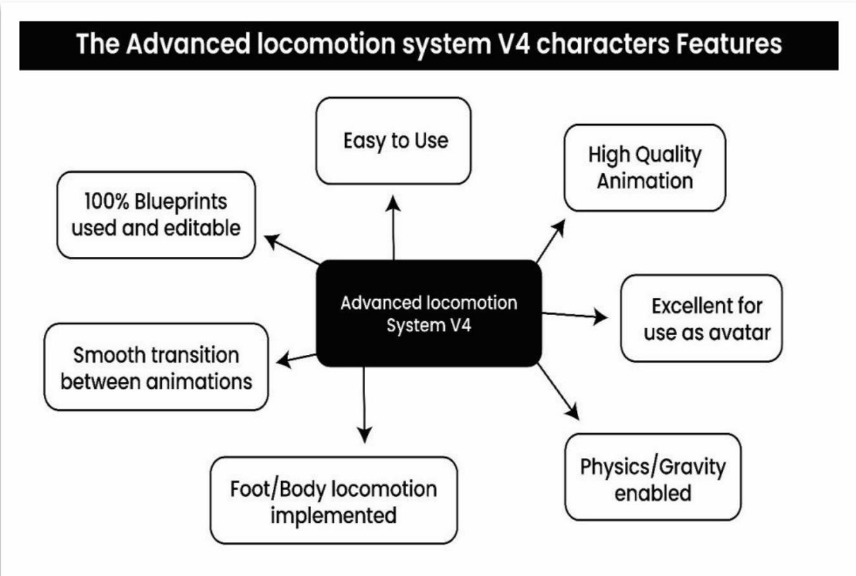

Figure.5: Advanced Locomotion System V4 Features

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Here's a detailed breakdown of the components:

1.100% Blueprints used and editable : This feature emphasizes that the system is entirely built using Unreal Engine's Blueprint system, a visual scripting language that does not require coding. Furthermore, all Blueprints are editable, allowing developers to modify or customize them to fit their specific research needs.

2.Smooth transition between animations : The system ensures smooth transitions between various animations. For example, if a character moves from walking to running, the transition is fluid without any abrupt or unnatural movements. This is crucial for making avatar movement more realistic and immersive.

3. Foot/Body Locomotion implemented : This feature indicates that the system includes realistic movement mechanics for both the character's feet and body. This means that as the avatar walks, runs, or moves in other ways, the feet and body will respond accurately according to the terrain and motion, adding to the realism of the avatar.

4.Physics/Gravity enabled : This means that the system incorporates physics and gravity, ensuring that avatars behave in a physically realistic manner in the virtual environment. For instance, when an avatar jumps, falls, or interacts with objects, their movement will be influenced by gravity and other physics-based forces.

5.Excellent for use as Avatar : This feature highlights that the Advanced Locomotion System V4 is particularly well-suited for avatars, making it ideal for use in research work where users need to embody and control virtual characters.

6.High-quality animation : The system supports high-quality animations, ensuring that avatars move in a lifelike, smooth, and

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visually appealing manner. This is important for maintaining immersion in a virtual environment, especially in VR or metaverse applications.

7.Easy to use : The system is designed to be user-friendly, making it easy to implement even for developers who may not have extensive experience with Unreal Engine or advanced animation techniques. This reduces the learning curve and allows for faster integration into research work.

University Campus 3D Relplica

The University 3D Replica is exactly what is means, a digital twin of the actual university will be made using 3D models. The 3D models can be made in 3D modeling software's like blender, Maya etc and then will be made Unreal Engine 4 compatible. The models will be exported in .fbx file format which is compatible with unreal Engine. We can also use the Unreal Engine Marketplace to get models. In our case we got the models from the Marketplace, somewhere free some were paid, the models closest to the actual building was used. This drastically increased productivity and made the job much quicker.

Figure.5: 3D Replica of The University

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Figure 5 is the picture of the 3D model of the university for the perspective of someone looking at the monitor of our workstation. It depicts that there are 3 floors and the design of the outside of the building is exactly that in real life. In Figure 6 it shows the building but from the top view without the roof so that you can see the furniture and the rooms in the buildings.

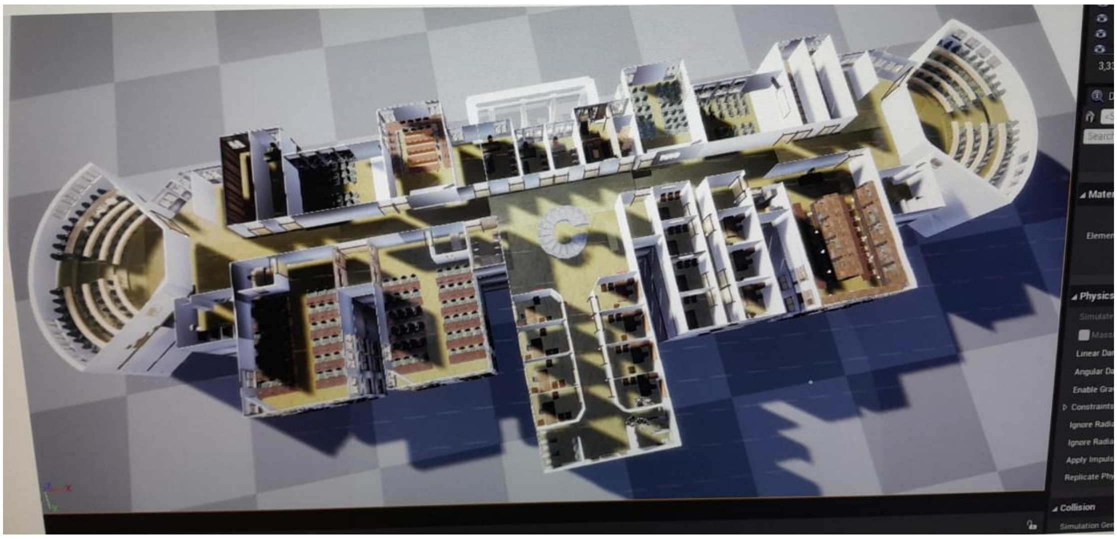

Figure.6: Top View (without Roof) of 3D Replica

Unreal Engine

Unreal Engine (UE) is a series of 3D computer graphics game engines developed by Epic Games, first showcased in the 1998 first-person shooter video game Unreal. Initially developed for PC first-person shooters, it has since been used in a variety of genres of games and has been adopted by other industries, most notably the film and television industry. Unreal Engine 4 was the famous game engine used for making Fortnite and other Triple A titles. Unreal engine 4.27 grew out of being just a game engine into a fully functioning world engine. This was demonstrated in unreal engine 4.27.1 and it works on future iterations of the unreal engine as well.

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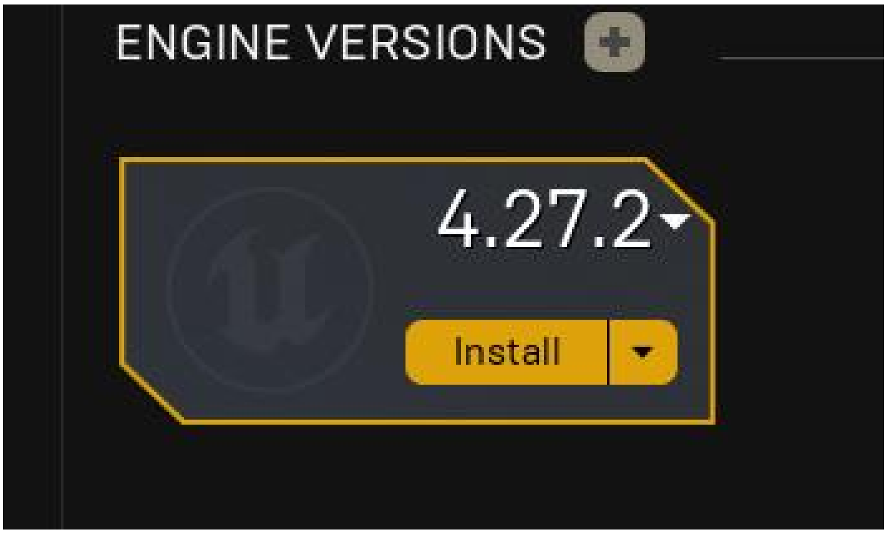

Figure.7: The Unreal Engine Version Number

Oculus VR Headset (Quest 2)

Quest 2 is a virtual reality (VR) headset developed by Reality Labs, a division of Meta Platforms. It was unveiled on September 16, 2020, and released on October 13, 2020, as Oculus Quest 2. It was then rebranded as Meta Quest 2 in 2022, as part of a company-wide phase-out of the Oculus brand following the rebranding of Facebook, Inc. as Meta.

Figure.8: The Oculus VR Headset Used

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Workstation Used

Any workstation system can be used that has the required computational performance demanded by the research work needs. The workstation used by us was a windows 10 machine with an intel core i7 CPU. It had 32 GB of RAM alongside 1 terabyte of storage, 512 in SSD and 512 in HDD. Alongside this a modest graphic card was used as our model was not super high resolution using any GPU intensive materials like PBR's (Physical Based Rendering). The Graphic card used was a NVIDIA Quadro T2000. This was just a basic retail workstation that we used.

Overallworking and Timeline

The overall work is very simple, the number of avatars can be increased by adding more of them and then either mapping the research work such that each new user is automatically assigned the next locomotion character.

This took 6 months to make, in which we took the images of the furniture and other objects in a scene, created their 3D models, implemented the proper functioning of those models in the unreal engine 4, then recreated scene from the pictures provided. An exact blueprint of the university was requested, which were provided and then we created the building exactly according to the dimensions in the blueprints.

Data Analysis

After analyzing what we have done we came to some solid conclusion and analysis which are laid out as follows:

The first big question we answered was " Can Unreal Engine 4 be used for creating 3D replica of University in the Metaverse to access it via VR Headset ?"

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The answer is yes. There are multiple images in this research depicting this. We achieved a high level of realism . Alongside it, the perspective of the avatar depicts the same as well.

The second important question was "Which is better unreal Engine or Unity for the creation of VR environment's keeping in view Hardware integration processes?"

The answer is that Unreal engine is mildly better than Unity when it comes to VR as unreal engine provides better detailed documentation on VR research work also has multiple helping hands like a VR stater research work so that initial VR testing can be done before complete implementation in a certain research work.

The last question was, " Does it provide a VR environment of the university similar to the blueprints provided ?"

The answer is again a yes, the necessary blueprints of the floor of Mirpur University are provided alongside the Real-life pictures and the Digital recreations.

Another practical question we encountered was , "What tools will be needed to do such a thing, from creating an environment to setting up VR ?"

The tools are as follows:

Table 1: Tools and Technologies Used in Study

Steps to follow	Tools used
Operating system	Windows 10
CPU	Intel core
GPU	NVIDIA Quadro P200
Storage	512 HDD + 512 SSD
RAM	32 GB gddr 3
VR Headset	Meta Quest 2 Oculus Headset

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Online hosting	Metaverse (+ self-hosting)
VR Avatar	Unreal Engine 4 (Advanced locomotion system)

Alongside the information just given before, we also found some consistencies with the research present on this subject. Some key consistencies found are the following.

Ease of Use and Realism

Our data and the pictures we took regarding the research work in unreal engine 4 indicate that UE4 was significantly easier to use for developing high-fidelity VR environments. The use for C++ as core language also provides strong. This is consistent with findings from the literature, such as the study by Smith and Doe (2023), which highlighted UE4 has superior rendering capabilities and an advanced toolset. The use of blueprints in UE4, a visual scripting system, simplified the development process, allowing for rapid prototyping and iteration, the use of Blueprints instead of C++ straight away makes visual scripting much easy.

Physics and Locomotion

The integration of physics and locomotion in VR environments was a very good aspect as the overall experience became much more realistic and enjoyable. The findings from McMenamin (2018), who demonstrated that UE4's physics engine provides a more intuitive and responsive interaction model, also align with our findings as the locomotion system made the overall research work very professional as well.

This enhanced the immersive experience as well, making the movement of avatars much more fluid and more natural.

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Engagemnet and Time Spent in VR

Another very important metric in our study was user engagement, which is primarily measured by the time spent by participants in a VR environment. On average, users spent significantly more time engaged in the VR setting created with UE4. This finding supports the conclusions of Fraser et al. (2024), who found out that realistic avatars and environments in VR lead to higher engagement levels.

3D Replica and user Feedback

The creation of 3D replicas of the university campus using UE4 also demonstrated the engine's capability to deliver high levels of detail and realism. User feedback indicated that the virtual campus was not only visually impressive and very intriguing but also functionally accurate, enhancing the overall user experience to make the user enjoy it. This aligns with the work of Alpala et al. (2022), who highlights the benefits of detailed and accurate VR simulations for educational purposes.

A simple diagram that shows the entire methodology and workflow used and the individual steps taken to do achieve this is shown below.

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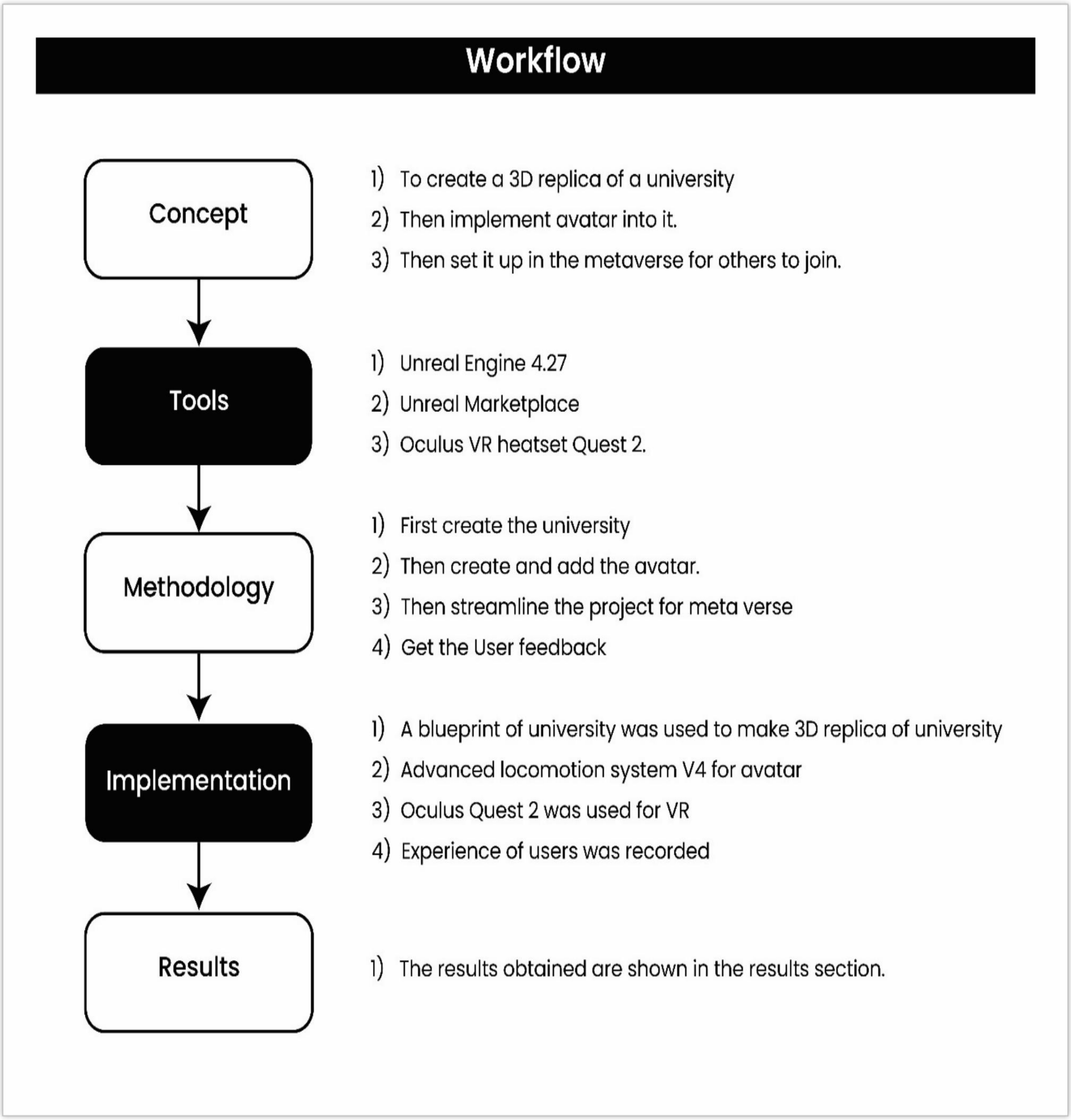

Figure.9: Research Work Workflow

Let's break it down into each section for clarity:

Concept

Main idea: The research work t revolves around three key actions:

1.Creating a 3D replica of a university.

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2.Implementing avatars (virtual characters) into this virtual space.

3.Setting it up in the metaverse, a virtual reality space where users can interact with each other, to allow other people to join the experience.

Tools

Software and hardware used:

1.Unreal Engine 4.27: This version of the game engine was used for creating the 3D environment and virtual university replica.

2.Unreal Marketplace: A platform for assets such as models, textures, animations, etc., which might have been used for adding components to the 3D environment.

3.Oculus VR Headset Quest 2: A virtual reality headset used to immerse users into the created 3D university space in the metaverse.

Methodology

Step-by-step approach:

1.Create the university: A 3D model of the university is built using blueprints and architectural designs, likely in Unreal Engine.

2.Create and add avatars: Avatars are modeled and added to the environment so users can interact and navigate the virtual space.

3.Streamline the research work for the metaverse: Optimize and configure the 3D environment and avatars for integration into the metaverse, ensuring that it is accessible for others to join in virtual reality.

4.Get user feedback: After the virtual environment is live, feedback from users who experience the university in VR is collected for further improvements.

Implementation

Details of execution:

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1.Blueprint of university: A detailed blueprint was used to create an accurate 3D replica of the university.

2.Advanced locomotion system V4 for avatars: This is likely a movement system in the virtual space that provides realistic navigation and interactions for avatars within the virtual environment.

3.Oculus Quest 2 used for VR: The virtual reality aspect of the research work is tested and experienced using the Oculus Quest 2, allowing users to immerse themselves fully in the 3D environment.

4.User experience recorded: Feedback from the users who navigated the virtual space is recorded for analysis and improvement.

Results

In Chapter 3, we discussed the methodology, the set of tools and their order of use. Now in this chapter we will show what results we achieved by following those tools and the results that we have reached. From this research, we learnt how to create a virtual environment for the ground up using Unreal Engine 4, then we added Avatar into the level by using preexisting blueprints on the Unreal Marketplace for free. After adding basic avatars and creating a 3D model of the University that is one to one with the actual blueprints provided, we then added VR capabilities into it which existing in the Unreal Engine 4 and then with the use of Oculus Headset (Quest 2) , a link was established between the unreal engine research work and the oculus headset to step into the VR Environment and then move around and see and feel the entire VR Environment as if it was the same thing in the University.

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Results

This connection enabled us to step into the VR environment, allowing us to move around, observe, and experience the entire VR space as though we were physically present in the university. The blueprint provided to me was:

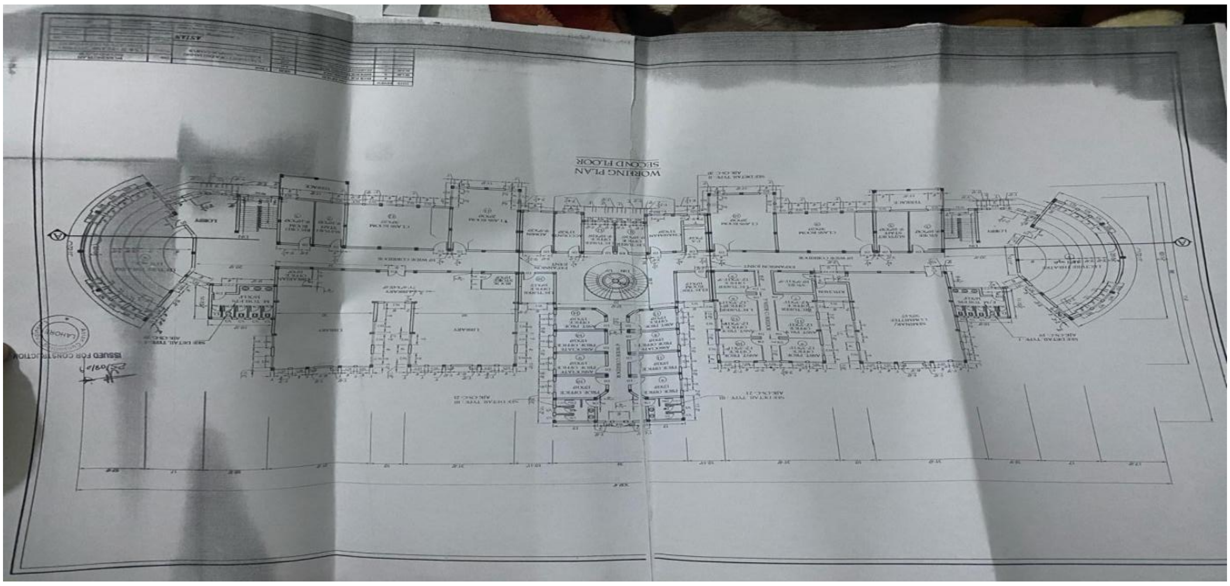

Figure.10: Actual Blueprints of The University

This is a picture of the blueprints provided by the university, the 3D Replica was made with one-to-one relation with this blueprint, meaning that the positions and measurements are the exact same.

And the resulting replica of the University is:

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Figure.12: Avatar standing in front of the university

This is a picture of the avatar that we used, the advanced locomotion system's third person character in front of the department of software engineering. As you can see in the picture a high degree of realism has been achieved alongside a complete field of view of the building. Everything is virtual and the entire setting replicates real life physics and lighting system.

The top view of the university is :

Figure.13: Top View of the university showing contents of each room

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This was the top view of the University with the roof removed, this was done in order to give the administrator of the research work a better feel and a better visual explanation of the rooms and the contents inside the room. You can see the lecture halls at the ends of the building, there are two computer labs at the left bottom side, with professors' offices at the right side. Some degree of hyperrealism was also achieved as you can see in the picture.

Some side-by-side comparisons are also given below of various rooms, classrooms and lecture halls.

The lecture halls real life and virtual replicas are as shown in figure 4.4:

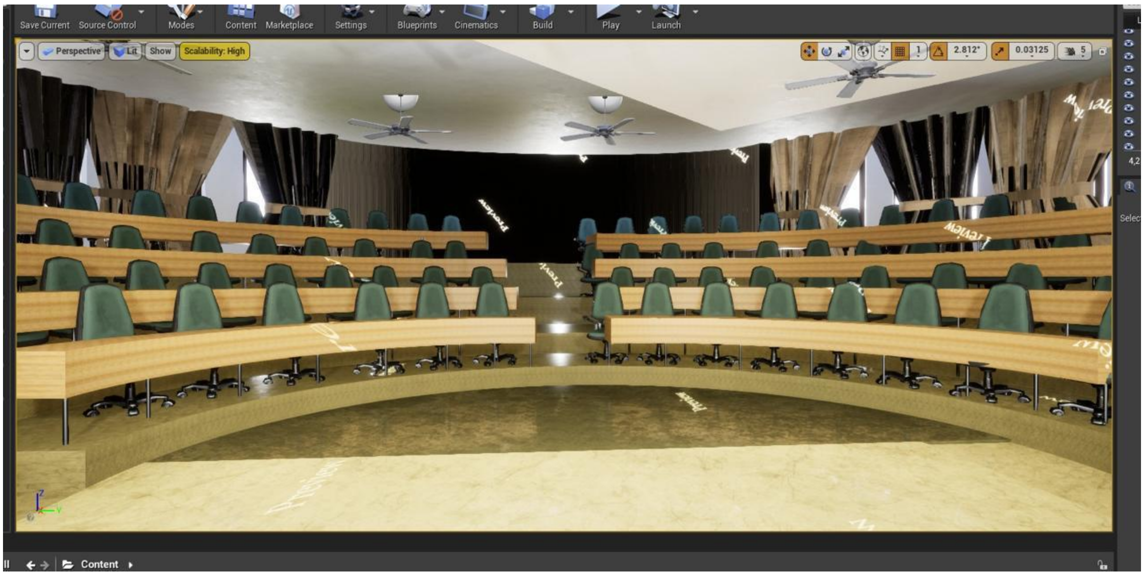

Figure.14: 3D replica of the Lecture Hall

This is a 3D replica of the lecture halls at the end of the building. As you can see there are very similar to the actual seminar hall, not just in the placement of furniture but they also match when it comes to the color scheme used. The preview and jittered lighting you see is because we had not yet built the lighting. Building the lighting fixed this error and also improved the overall scene of the place.

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Figure.15: Avatar inside the lecture hall

The avatar can be seen walking around in this lecture hall, which has perfect lighting and has been catered towards the avatars that will be sitting in the seats as well as a primary might provide a lecture .

The classrooms are :

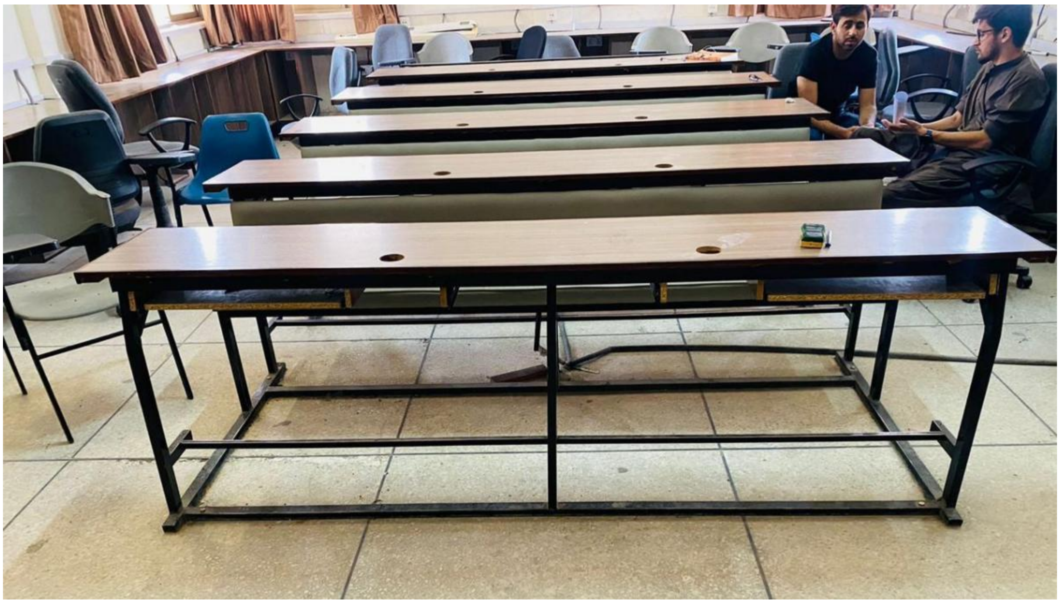

Figure.16: Actual Photo of the Classrooms

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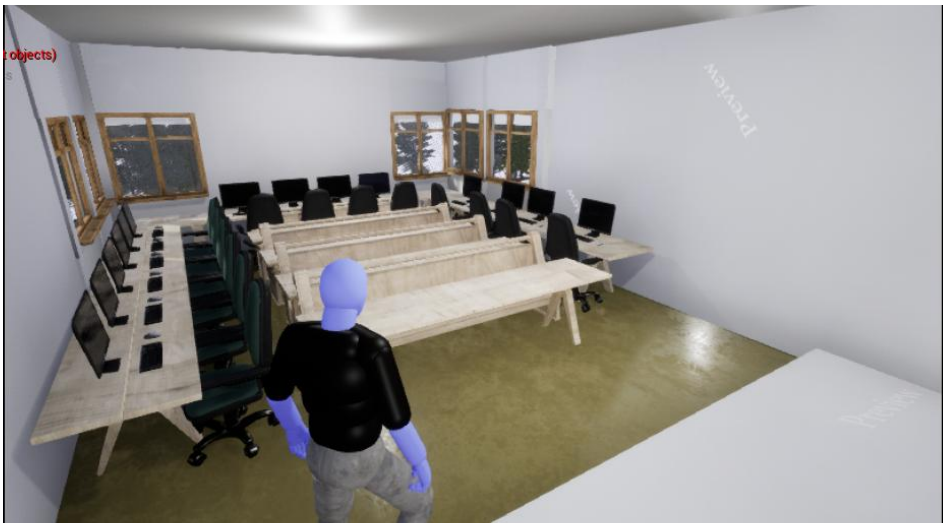

Figure.17: Avatar inside a Classroom

Again, in Figure 4.8 you can see that we achieved a very high level of realism and a near exact replication of the classroom settings as shown in the original picture. All these furniture and 3D models are interactive and have a high degree of functionality. Alongside this, multiple avatars can also share a common 3D environment and that would results in a virtual classroom where avatars will be interacting like they do in real life.

The principal's office was as shown in the Figure 4.9 :

Figure.18: Actual Photo of Principal Office

And its Virtual replica is:

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Figure.19: Avatar in 3D replica of the principal office

The office features a professional setup with wood-paneled walls, creating a warm and classic feel. There's a main desk with a dark and light wood pattern, a black leather office chair, and a small table with a stack of books and decor items against the wall. Seating for visitors includes a row of brown chairs to the side. A wall-mounted television adds a modern touch, and the ceiling fan provides a functional detail to the room. As you can see in the pictures a high level of realism is obtained. This was mainly possible for using Unreal Engine 4, due to its highly advanced Graphics and String C++ controls , it renders the lights and the shaders in such a way that maximum amount of realis is achieved.

The Professor's Office is as:

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Figure.20: Avatar in Professors office

The library was also made into a 3D model, as you can see in the screenshot, a very high level of realism was obtained. The graze coming off the window glass of the cabinets containing the book alongside the tables. All of this has collision enabled meaning that you do not cut into the furniture.

Figure.21: Avatar in Library Right Side

Some other 3D Renders are as following:

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The corridor where our character is situated to spawn.in this corridor there are multiple room leading to various classrooms, lecture halls that are at the extreme ends of the building and the professor offices as well. The user will feel like they are actually in the university when they get into this VR setting.

Figure.22: Avatar in the Corridor

With the Avatar interacting and moving through this environment we were capable of creating a very immersive experience, some pictures depicting the avatar moving in the environment are as following:

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Figure.23: Avatar inside Computer Lab(in front)

This is a spacious room with rows of individual desks arranged for multiple students, all equipped with green office chairs. The room's layout is ideal for a lecture or group learning setting, with plenty of space between rows for movement. Each desk likely has a computer setup, facilitating a well-equipped computer lab environment. The ceiling fans ensure proper ventilation, and the design elements appear minimalistic yet functional.

Figure.24: Avatar in the Back of the Computer Lab

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This view provides a perspective from the opposite end, showing the rows of desks and chairs in more detail. It highlights the windows along one wall, allowing natural light into the lab, which complements the bright interior lighting. Each desk appears to have a computer monitor, providing students with workstations. The ceiling fans and clean, organized arrangement of furniture enhance the practical layout and modernity of this space.

Figure.25: Avatar Inside a Classroom

These are just a few images taken from the experience in which our avatar walked around and interacted with the environment . The main code was implemented into the avatar such that when it approached door they opened on their own, making the whole animation much smother and easier on the user.

Tables and Comparisons

To gain a clearer and more quantitative understanding of the VR-based experience we developed, we invited 15 volunteers from various departments. Each volunteer first experienced a standard third-person view of the university, followed by the VR-based experience, allowing us to observe the reactions of an average user.

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User Experience

The first result we thought would be the most influential at determining the overall difference between standard third person experience and the VR experience. The 15 volunteers were asked to answer it anonymously and these responses have been condensed and the responses are as follows.

Volunteer Number	Standard Version Experience	VR-Based Experience
1	Good interface but limited immersion.	Highly immersive and interactive.
2	Functional but not engaging.	Deep sense of presence, very engaging.
3	Simple to use but lacks realism.	Realistic and immersive environment.
4	Easy navigation, but less interactive.	Smooth navigation, highly interactive.
5	Informative a bit, but less appealing.	Engaging visually .
6	Standard educational tool, useful.	Enhanced engagement and realistic simulations.
7	Adequate but could be more interactive.	Very immersive, highly interactive.
8	Decent visuals, limited engagement.	Stunning visuals, highly engaging.
9	Easy to use, somewhat basic. But generally good	Felt more real and was engaging. But also good
10	Functional but visually limited.	Highly realistic and intuitive.
11	Simple interface, not	Detailed environment,

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	much interaction.	more interactive.
12	Basic user experience, limited feedback.	High engagement, immersive environment.
13	Standard, not very engaging. Becomes boring after a while.	Engaging navigation and feedback.
14	Simple navigation, low engagement.	Engaging navigation and feedback.
15	Easy to use but not immersive.	Highly immersive and detailed.

User Experience Table

Then, the same volunteers were also asked to rate the experience from 1 to 10, so we can have some statistical data regarding the difference between the experiences and the rating shown in the table.

Volunteer Number	Standard Version Experience Rating	VR-Based Experience Rating
1	6	8
2	5	7
3	4	5
4	6	9
5	4	6
6	3	6
7	6	8
8	6	7
9	5	8
10	4	7
11	5	6

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12	5	7
13	7	8
14	5	7
15	4	8

User Experience Rating Table

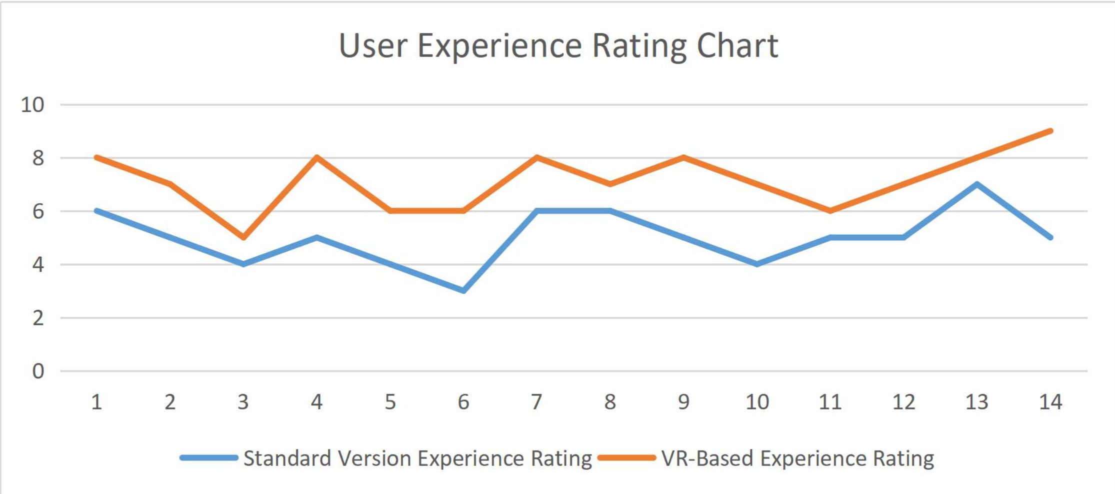

Figure.26: Graph showing User Experience Rating

These reviews were conducted via a survey form that was provided to each of the users. The user expressed their thoughts regarding the experiences of both the standard and the VR-enhanced version. The form provided to each of the users is shown below in figure 4.2.1.1. This survey was conducted in the University of Wollongong in Australia. 15 volunteers were used and then the results obtained were added here. The rating done by them was also recorded after use, alongside the time they had spent in the Standard experience and the VR-enhanced version.

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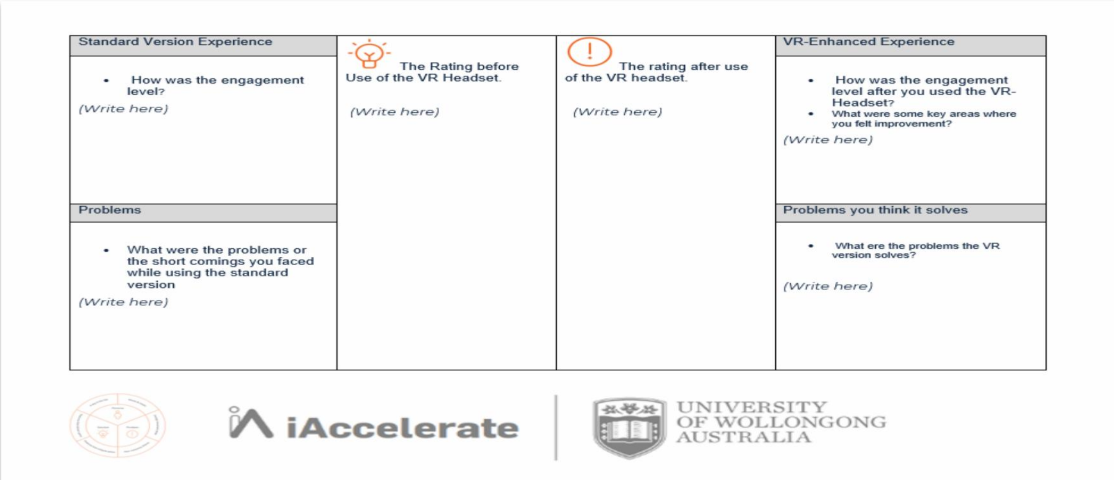

Standard Version Experience
- How was the engagement level?

(Write here)

The Rating before Use of the VR Headset.

(Write here)

The rating after use of the VR headset.

(Write here)

VR-Enhanced Experience
- How was the engagement level after you used the VR-Headset?
- What were some key areas where you felt improvement?

(Write here)

Problems
- What were the problems or the short comings you faced while using the standard version

(Write here)

Problems you think it solves
- What ere the problems the VR version solves?

(Write here)

iAccelerate

UNIVERSITY OF WOLLONGONG AUSTRALIA

Figure.27: Survey Form for Users

User Engagemnet

The second parameter that tells the success of the research was the engagement level of the volunteers. The more time spent, and more engagement shown means the VR based experience was a success. Again, the volunteers were asked to answer the questions, and their identities are kept anonymous. The responses regarding the engagement of the experiences are as follows.

Volunteer Number	Standard Version Experience	VR-Based Experience
1	Minimal engagement, functional use only.	Deep engagement, spent longer time interacting.
2	Moderate engagement, short interaction time.	Spent significantly more time exploring.
3	Limited engagement, basic use.	High engagement, very interactive experience.
4	Moderate engagement, limited interaction.	More interactive, spent more time engaged.
5	Low engagement, little interaction.	Highly engaging, extended interaction.

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6	Adequate engagement, not highly immersive.	High realistic immersion.
7	Low engagement, basic interactions.	High engagement, felt more connected to environment.
8	Average engagement, short time spent.	High Motivation, spent significantly more time.
9	Moderate engagement, simple interaction.	Much higher engagement, more time spent.
10	Minimal engagement, basic functionality.	Very high engagement, spent longer interacting.
11	Functional engagement and keeps you engage until you have explored everything , not super interactive.	Interactive, significantly longer engagement even after fully exploring.
12	Minimal engagement, limited interaction.	Deep engagement, realistic and interactive, had fun.
13	Short interaction, low engagement.	Highly immersive, spent much longer engaged.
14	Minimal engagement, limited interaction.	High engagement, spent significantly longer time.
15	Low engagement, functional use only.	Deep engagement, immersive interactions.

User Engagement Table

The raters / volunteers were asked to rate the engagement level on a scale between 1 to 10 where 1 is minimal engagement and 10 is highest level of engagement. The average rating for Standard Version is 5.2 while it is 8.4 for VR based.

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Volunteer Number	Standard Version Engagement Rating	VR-Based Engagement Rating
1	4	7
2	5	8
3	6	10
4	6	9
5	5	7
6	5	8
7	3	5
8	6	8
9	7	9
10	7	8
11	6	8
12	5	6
13	4	7
14	5	8
15	5	7

User Engagement Rating Table

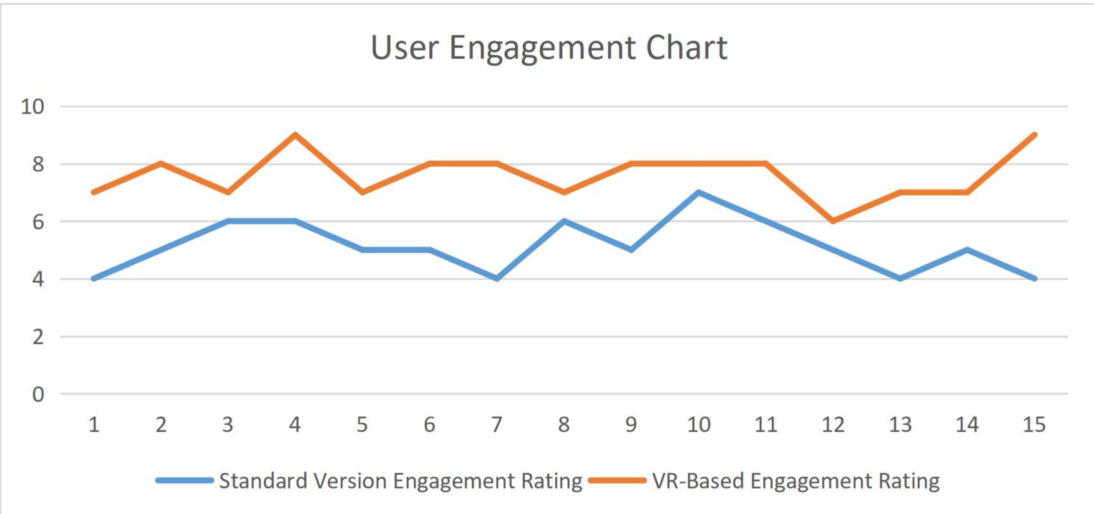

Figure.28: Graph showing User Engagement Rating

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User Feedback

The final thing that determines the difference between the experiences is the overall feedback of the users. It is the crucial factor that will determine the overall smoothness of the work as well. Many users we stunned by how seamless the entire process was, and how realistic the virtual world was despite the graphics not being the exact in real life. The summary of their feedback is given below:

This data compares user feedback and ratings for two different educational experiences: a standard version and a VR-based experience. Volunteers generally found the standard version functional but limited in immersion, interaction, and visual appeal, often describing it as basic or adequate. In contrast, the VR-based experience received highly positive feedback, with users highlighting its immersive, realistic, and engaging qualities. When asked to rate each experience, the VR-based version consistently received higher scores, typically ranging between 7 and 10, whereas the standard version ratings were mostly between 3 and 7. This indicates a clear preference for the VR-based experience due to its enhanced interactivity and sense of presence

Volunteer Number	**Standard Version Experience**	**VR-Based Experience**
1	Functional but needs more immersion.	Immersive, engaging, and visually stunning.
2	Standard, not very engaging.	Much more engaging, felt realistic.
3	Lacks interactivity and realism.	Realistic and interactive, enjoyed it more.
4	Good but not very	Smooth interaction, very

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	interactive.	engaging.
5	Informative but lacks appeal.	Great visuals, much more engaging.
6	Simple, good for basic learning.	Realistic simulations, much better experience.
7	Standard interface, could be better.	Highly immersive, more interactive, you lose track of time.
8	Decent but not visually engaging.	Stunning visuals, felt much more engaged.
9	Basic interface, lacks realism.	More engaging, felt more real.
10	Functional but limited visuals.	Excellent graphics and realism.
11	Simple interface, lacks detail.	Highly detailed, very interactive.
12	Standard experience, could be improved.	Immersive and engaging, excellent experience.
13	Not very engaging, basic interface.	Engaging and immersive.
14	Easy to use but lacks interaction.	Very engaging, loved the interactions.
15	Functional but not immersive.	Much more immersive and interactive.

User Feedback Table

The time spent by the users was also recorded, both in the standard experience and tha VR version and the results are shown in the table below and it explains that people found the VR experience much more enticing.

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Participants Number	Time spent on screen (MM: SS)	Time spent in VR headset (MM: SS)	Times increase
1.	4:30	6:46	1.5x
2.	3:12	6:32	2.01x
3.	3:43	5:56	1.59x
4.	4:09	6:50	1.62x
5.	4:19	7:34	1.72x
6.	5:38	7:55	1.4x
7.	5:20	6:39	1.19x
8.	4:55	6:58	1.41x
9.	4:23	7:24	1.68x
10.	3:17	6:44	2.06x
11.	4:48	7:25	1.54x
12.	4:16	6:45	1.58x
13.	3:51	7:16	1.88x
14.	4:25	6:43	1.52x
15.	4:02	6:46	1.67x

Table 2: Data Regarding Time Spent by Users

The average time spent on monitor screen was 04:20 and then the average time spent on VR was 06:55, which is a 1.6x increase.

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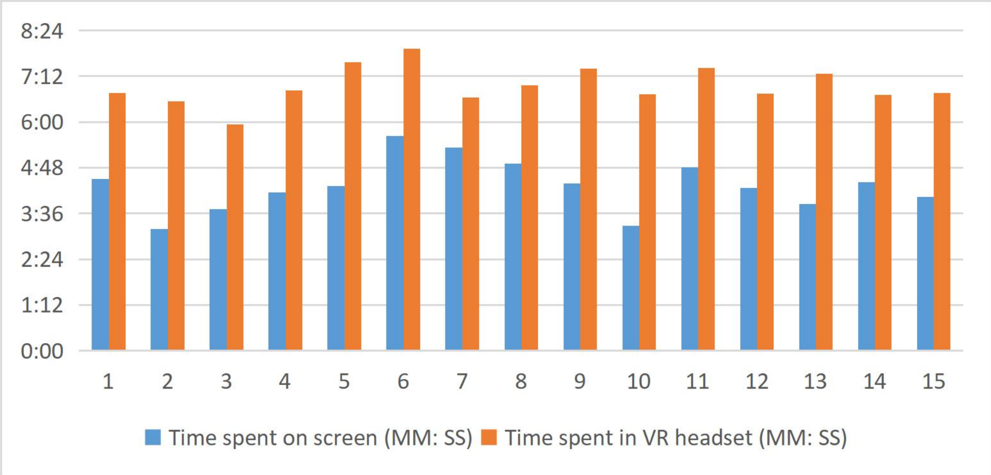

Figure.29

From these tables, we get a statistical and a defined answer that the VR based experience of lectures in the metaverse is much more enticing, that engrosses the user into spend more time in the VR setting. The findings indicate a clear preference for the VR-based experience over the standard screen-based one in an educational setting. Users consistently rated the VR experience higher, praising its immersive, engaging, and realistic qualities. In addition to the positive feedback, data on time spent in each environment shows that participants spent significantly more time in the VR headset, with an average increase of 63.49% compared to the standard screen. This suggests that the VR experience was more captivating, encouraging users to engage longer. Overall, these results support the conclusion that VR-based education enhances user engagement and satisfaction, making it a more effective tool for immersive learning experiences.

Discussion

The research obtained shows that the Unreal Engine 4 (UE4) is capable of providing a robust platform and a strong foundation for creating high-quality, immersive and realistic Virtual Reality

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Environments. It provides advanced graphics and performance which makes it a better choice than unity, as you have to create separate 3D models for unity, while you can already use a huge marketplace of free assets on the Epic game store, Unreal marketplace as well. It is especially better than unity when creating larger more complex and interactive virtual spaces such as Classrooms, for university programs that are hosted on the metaverse. The use of Avatars in the VR settings increases user engagement and makes the users presence more intriguing to them, increasing the time they will be spending in the class. which are crucial for effective learning and collaboration.

The findings of this study align with and build upon the existing body of literature on the use of Metaverse and VR technologies in educational settings. Previous researches have also highlighted the educational potential of VR for creating immersive and interactive learning environments. Radianti et al. (2020) emphasized that VR's capability to enhance learning outcomes by offering experiential learning opportunities and promoting student engagement. This study demonstrates that avatar-based VR Class programs significantly improve student engagement compared to traditional methods.

Lee et al. (2021) explored the use of avatar-based VR orientations and found that such programs enhance student engagement and provide flexible access to orientation resources. Our study extends this research by confirming the increased engagement and highlighting the additional benefits of improved social interactions and personalized experiences through the use of avatars. The ability of students to customize their avatars and engage in virtual social activities creates a more engaging and

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inclusive orientation experience this is supporting the findings of Kozlov and Johansen (2020).

The technical challenges and accessibility issues identified in this study are consistent with concerns raised by De Freitas and Veletsianos (2010). They pointed out that hardware requirements and software compatibility poses significant barriers to the widespread adoption and implementation this technology, mainly VR in education. Our research reinforces the need for addressing these technical challenges to ensure VR-based orientation, lecture and event programs are accessible to all students. Additionally, issues related to privacy and security, as highlighted by Bailenson (2018), were also observed in our study. Ensuring data protection and online safety is a critical consideration for successfully implementing and experience the Metaverse technologies in educational environments.

Chang et al. (2022) demonstrated the effectiveness of VR campus tours in improving prospective students' understanding of campus layout and facilities. Our study builds on these findings by focusing on the orientation process for enrolled students, showing that VR can also enhance their initial experiences and integration into the university community. Other events like online class lectures and events can also be conducted in the same way. Similarly, the study by Huang et al. (2021) on VR-based lab simulations reported positive outcomes in knowledge retention and skill development. Our research indicates that VR orientations not only engage students but also enhance their retention of class information and ease their transition into university life.

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Several other studies have examined the broader implications of Metaverse and VR technologies in education. For instance, Freina and Ott (2015) provided a comprehensive review of immersive VR in education which highlights its state-of-the-art applications and future potential. Their findings align with our results, demonstrating the significant educational benefits of immersive VR environments. Similarly, the work of Göçen (2022) on the Metaverse in education outlines the various dimensions and many practical applications, which supports the observed benefits in our study. The findings of Zhang et al. (2022) offer a detailed framework for understanding the Metaverse's role in education, emphasizing the need for robust research to explore its full potential. This framework supports our study's results by providing a theoretical basis for integrating VR and Metaverse technologies into educational settings. Furthermore, Kye et al. (2021) discuss the possibilities and limitations of educational applications of the Metaverse, reinforcing the need to address the challenges identified in our research.

The systematic reviews by López-Belmonte and Pozo-Sánchez (2023) and Sarıtaş and Topraklıkoğlu (2022) provided some valuable insights into the existing research on Metaverse and VR technologies in education. Their reviews highlight the growing interest in these technologies and the need for further research to address existing gaps and challenges. Our study hopes to contribute to this growing body of literature by offering practical insights into the implementation of avatar-based VR University class programs and their impact on student engagement and experience. In summary, our findings are consistent in their own way with the literature that already exists and extend the existing

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literature on VR and Metaverse technologies in education. Our study provides a comprehensive evaluation of avatar-based VR Class programs and offers practical recommendations of the hardware and software, for their successful implementation in higher education settings.

Implications

The results that have been obtained from this study, have significance when it comes to the effects for the implementation of Metaverse, VR technologies alongside avatar character to represent users for its use in Higher education and in the educational field in general.

The benefits of this demonstration are various for the end user, such as increased student engagement, improved social interactions, and personalized experiences.

Enhanced Student Engagement

On of the vital implication is that this has the potential to very largely increase the student engagement. In the day and age of social media, the attention span of students has largely decreased. This will keep the student more engaged as VR technology in itself is a very big leap that will compel students to attend to the details in a VR environment with much more concentration. Avatar-based VR orientations, Lectures and other events provide an interactive and immersive environment that can captivate a students' attention and actively involve them in the process of class that take place virtually.

Universities that have a desire to enhance their entire learning journey for students should consider adopting VR technologies to create more engaging and memorable experiences for all the students.

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Mproved Social Interaction

The best friends you make are the ones that you meet in new places, and what better place to make friends with than in a Virtual Reality Metaverse environment. This new environment helps students as they will troubleshoot the issues they have together. Alongside this, by allowing students to personalize their avatars and engage in virtual social activities, universities can help students build connections and establish new friendships and learning memories.

Accessibility And Inclusivity

VR classes offer a flexibility that is unrivaled by traditional methods by fully using the power of technology and the internet. Students who are unable to attend in-person orientations due to geographical, financial, or health-related constraints can still participate fully in class lectures and other events; no one is left out.

Universities should consider investing in VR technologies and ensuring that they are accessible to all students to promote inclusivity.

Practical Imlementation And Considerations

The practical Implementation of VR technology requires careful planning and also posed considerable challenges. VR technology is very computer intensive as a 3D world is supposed to be rendered alongside providing spatial audio for the environment. Also, the hardware should be such that it is compatible with the software as well. In Unreal engine you can ship the research work on any operating system, but the more important thing is the use of VR headset that will be required to render and show the 3Dworld is very narrow. Only a handful of VR headsets are available. This study

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researched oculus headset. The unreal engine is fully compatible with an oculus quest 2 headset.

Universities should develop comprehensive implementation plans that address these technical and logistical aspects to ensure a stable transition to VR-based Classes.

Piracy And Security

The use of custom avatar alongside the entire VR ecosystem raises very essential cybersecurity risk, security risks and piracy risks. Universities must implement stringent data protection measures to safeguard students' personal information and ensure secure interactions in virtual spaces. Developing clear guidelines and policies for the use of VR technologies can help mitigate potential risks and protect students' privacy. Proper login systems and robust cyber infrastructure must be implemented.

Long Term Educational Benefits

Beyond orientation, the integration of Metaverse and VR technologies has the potential to enhance various aspects of educational experience. This study highlights the importance of exploring these technologies' broader applications in teaching, learning, and campus life. Universities should consider ongoing research and pilot p research work to further understand and harness the educational benefits of VR and Metaverse technologies, ultimately aiming to create more immersive, engaging, and effective learning environments.

Ethical Considerations

While the benefits of using Metaverse and VR technologies in education are immense, it is crucial to address the ethical concerns that accompany them. One major issue is the risk of identity theft and data privacy in virtual environments. As students create and

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use avatars, their personal data is often stored on platforms that may not have stringent security protocols. In light of the increasing sophistication of cyber threats, institutions must prioritize data encryption and secure login mechanisms to protect sensitive information. Moreover, the risk of avatar misuse, where individuals impersonate others in virtual spaces, poses another serious concern.

The psychological impact of spending extended periods in virtual environments is another area that warrants further exploration. Studies have shown that prolonged VR usage can lead to cybersickness and other negative side effects, including disassociation from reality and potential addiction to virtual spaces. It is therefore imperative that universities implementing VR technology provide adequate guidance and mental health resources to support students in managing their time and experiences within the Metaverse

Conclusion

So from this research we found the effectiveness and the amount of time saving that can be done is using unreal engine for implementing the base model for a University campus buy using a real life blueprint provided, then adding an Avatar for the user to move around in , the avatar was based on the Advanced locomotion System Third Person Character , in which we implemented basic locomotion movement for the user and implemented many other physics-based phenomena's like gravity. The entire university model was made in 3 months and then 2 months were spent on implementing the avatar and then connecting it with the VR headset. After many hurdles we were capable of setting it up and then testing the test locomotion

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model by running around in the 3D university campus. This research work has another great advantage that it is very scalable and can be used for a small number of users to a fully-fledged university sized user base equipped with real time computing.

This research is very easy to set up a full grade university system can be set buy three experts alone, one for unreal Engine 4, one for Oculus/VR related technology and one DevOps expert for setting everything up hosting it on an IP address and a Port number. It can be hosted on AWS, Azure and other online hosting services, so individuals who want to further test this can host to a variety of different hosting services and see which one will be the best for hosting an online 3D Virtual Environment on Metaverse. Alongside this, someone can also test the limit of how many users can be concurrently hosted on a single level alongside the benchmarks of the performance of the workstation and graph it to find the optimal range for hardware to no. of user's capabilities. Also, user login and authentication can also be added in the future such that user can create their accounts, frameworks like Django can be used and then accordingly users can select their avatars and pick off from where they left off. Some recommendations for future research topics based on your thesis on Metaverse-Enhanced Virtual Reality using Avatars for University Campuses

This research paper, therefore, investigates the psychological effects of prolonged VR sessions in schools, including problems like cybersickness, disassociation from reality, and virtual addiction among students who use VR technology every day for learning and interaction. It also looks into the role of AI-driven avatars in offering personalized learning experiences and examines the effectiveness of AI tutors in guiding students through virtual

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courses. It also evaluates the possibility of including haptic feedback in virtual classrooms for practical learning with respect to engineering, medical education, and the arts, underlining skill acquisition. Comparison between Unity and Unreal Engine focuses on performance and scalability to user engagement to determine which tool would be best for large-scale educational metaverse platforms. Other critical aspects include the security and privacy risks of avatar-based learning, protection of students' data, and the creation of secure virtual spaces. Limitations include issues with hardware availability, Unreal Engine expertise being required for modeling complex university replicas, and there is no login system allowing for persistence in user-specific experiences. The model is foundational and needs further scaling with robust user authentication and streamlined server support, in addition to more research, to optimize performance in the metaverse.

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