Design Of Virtual Classroom Using Unity 3D

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***Abstract*—The rapid evolution of virtual reality (VR) technology has redefined digital education by enabling immersive and interactive learning experiences. This paper presents the design and development of a VR-based virtual classroom using Unity3D, integrated with the Meta-Quest 2 headset to enhance engagement and accessibility. The proposed system features a structured virtual environment, including a start scene, a lobby, a login system, and a classroom where students and instructors interact in real time. The virtual classroom facilitates lecture delivery through PowerPoint presentations while incorporating Photon Chat and Photon Audio for seamless text and voice communication. This interactive framework closely replicates physical classroom dynamics, improving remote learning effectiveness. The integration of VR technology ensures an immersive, presence-driven educational experience, bridging the gap between traditional and online learning methodologies. Experimental analysis demonstrates the system's effectiveness in enhancing student engagement and participation. This research underscores the potential of VR-driven learning environments in overcoming geographical barriers and fostering innovative educational solutions.**

***Index Terms*—Virtual Reality, Virtual Classroom, Unity3D, Meta-Quest-2, Photon Networking, Remote Learning, Immersive Education, Real-time Interaction**

I. INTRODUCTION

Virtual Reality (VR) has dramatically transformed the educational experience, offering immersive and interactive learning environments where students can actively engage in their education. Unlike traditional learning methods, where students are passive recipients of information, VR-based education allows students to step directly into a digital classroom, engaging with both content and peers in real-time. This immersive nature of VR significantly enhances student interaction, making learning more engaging, accessible, and personalized. Through this immersive quality, VR has demonstrated potential to improve learning outcomes by providing students with dynamic, hands-on experiences that were once impossible in a physical classroom setting.

Virtual Reality, as a technological medium, has not only revolutionized the entertainment and gaming industries but also made significant strides in sectors like education, healthcare, and professional training. VR enables users to explore and interact with environments in ways that go beyond traditional screen-based learning. In the realm of education, VR allows for the creation of virtual classrooms where students, regardless of location, can attend lectures, participate in discussions, and collaborate with peers, making it a transformative tool in the evolution of digital education. This technology, when applied to educational settings, has the potential to redefine the classroom experience by making it more interactive, accessible, and engaging.

Traditional education methods, while effective, often lack the interactivity and flexibility that modern learners demand. Conventional classrooms, though structured, limit student engagement, often leaving students as passive recipients of lectures. Virtual classrooms address these challenges by offering interactive, dynamic learning spaces that allow students to be active participants in their education. By incorporating real-time communication, collaborative tools, and immersive environments, virtual classrooms have the power to create more engaging and effective learning experiences.

The development of virtual classrooms also addresses significant issues of accessibility in education. Geographical and physical constraints have long prevented many students from accessing quality education. Virtual reality offers a solution to this challenge by allowing students to attend classes from anywhere in the world. The ability to attend lectures virtually and interact with peers and instructors in real-time eliminates the barriers of distance and physical location, making education more inclusive and accessible to all.

Virtual Reality (VR) is evolving in the context of education, much like how it has transformed other industries such as entertainment. In educational settings, VR is being leveraged to create more engaging and immersive learning experiences. Instead of merely watching or listening to a lecture, students can now interact with the material and the instructor in a more immersive and meaningful way. The integration of VR with educational content allows for real-time participation, where students can move around virtual spaces, engage in discussions, and collaborate on projects, offering an experience far beyond traditional methods.

Advancements in VR technology, including the development of headsets like Meta-Quest 2 and integration with platforms like Unity3D, have made the creation of immersive educational experiences easier and more accessible. With Unity3D's powerful development environment and the capabilities of VR headsets, developers can now create virtual classrooms that replicate the dynamics of a physical classroom. These tools enable a high level of interactivity, such as avatar-based communication, collaborative workspaces, and real-time feedback, which significantly enhance the student experience.

This project focuses on developing an interactive virtual classroom using Unity3D, with the Meta-Quest 2 headset as the primary interface. The objective is to create a virtual learning environment that allows students to attend lectures, interact with instructors and peers, and engage in real-time discussions. By using Unity3D's 3D modeling and networking capabilities, this virtual classroom aims to provide an engaging, accessible, and flexible learning experience, bridging the gap between traditional and online education. The project seeks to offer a solution to the growing need for immersive and interactive learning platforms, combining cutting-edge technology to create a meaningful educational experience.

II. RELATED WORK

Virtual Reality (VR) in education has grown significantly, with uses ranging from virtual classrooms to interactive learning tools. VR creates immersive spaces that allow students to actively engage with their learning, making the experience more interactive. This helps students connect more deeply with the material, improving their understanding and involvement. VR has the potential to transform digital learning by allowing students to interact with content, instructors, and peers in real-time, leading to better learning outcomes.

Ratun Rahman and Md Rafid Islam (2023) [1] introduced VREd: A Virtual Reality-Based Classroom for Online Education Using Unity3D WebGL, a cloud-hosted VR application accessible across multiple platforms. The system enables real-time interaction, adjustable camera positions, and customizable environments, providing a more engaging learning experience. It supports SaaS-based education, allowing students to access materials anytime and teachers to manage classroom interactions. VR enhances visualization, overcomes language barriers, and improves engineering training. While it offers many benefits, the system also aims to minimize VR's impact on social interactions.

Kodai Oiwake, Kosuke Komiya, and Hina Akasaki (2021) [2] developed a multi-user VR classroom system that enables real-time interaction between students and teachers using avatars and text chat, aiming to enhance engagement and learning experiences through the ARCS motivation model. Built in Unity, the platform utilizes a PC server and HTC Vive controllers for user interaction. However, some students found the anonymous text chat feature too casual, and the system lacked the capability for students to take notes or refer to external materials during the lectures, highlighting areas for further improvement in virtual classroom experiences.

Sharad Sharma, Ruth Agada, and Jeff Ruffin (2021) [3] proposed a virtual reality classroom as a constructive approach, replicating real learning conditions with an interactive simulator. Built using 3DS Max and WorldViz Vizard, the system features narrated animations, AI-driven question-answer dialogs, and multi-user collaboration. The design focuses on navigation, interaction, and presence, with Vizard scripts enabling animations and collision detections. While multi-user functionality is implemented, improvements are needed for AI students, physics realism, and alternative input methods like HMDs and Kinect.Salas-Pilco, S. Z., Yang, Y., and Zhang, Z. (2021) [4] analyze factors influencing student engagement in online education in Latin American higher education during the COVID-19 pandemic. The study highlights challenges such as digital access, motivation, and instructor support while also identifying strategies to enhance participation. The findings emphasize the importance of interactive content, technological infrastructure, and institutional support in improving online learning experiences. Furthermore, the study underscores the role of social presence and community building in fostering a sense of belonging among online learners, which is critical to sustaining engagement. It also suggests that improving faculty training and providing students with technical resources can mitigate many of the barriers that hinder effective online learning in this region.

Greenhow, C., Graham, C. R., and Koehler, M. J. (2021) [5] examine the fundamental aspects of online education, highlighting both its potential and limitations. The study discusses challenges such as digital equity, learner engagement, and instructional design, while also exploring opportunities for personalized learning and innovative teaching strategies. The findings emphasize the need for effective pedagogical frameworks to enhance the quality and accessibility of online learning. Additionally, the research calls for the development of adaptive technologies that can cater to diverse learning needs, ensuring that online education is equitable and effective for all students. The authors suggest that future research should focus on exploring how technology can be leveraged to foster collaboration and social interaction in online environments, thus addressing the isolation often felt by remote learners.

Li, D. (2020) [6] explores the impact of online learning during the COVID-19 pandemic, focusing on the benefits and challenges faced by students. The study highlights key benefits such as flexibility and accessibility while also addressing challenges like technical issues, lack of engagement, and the need for better instructional design. The findings emphasize the importance of improving online learning environments to enhance the student experience and effectiveness. The research also suggests that a blended approach, incorporating both synchronous and asynchronous elements, can improve engagement and overall learning outcomes in virtual settings.

Makransky, G., and Mayer, R. E. (2016) [7] examine how immersive virtual reality (VR) enhances learning experiences. The study supports the immersion principle, demonstrating that virtual field trips improve engagement, knowledge retention, and conceptual understanding compared to traditional learning methods. The findings highlight VR’s potential in multimedia learning by providing interactive and realistic educational experiences. By engaging students in a more immersive environment, VR enhances motivation and fosters deeper cognitive processing, making it a valuable tool in education. However, the research also discusses challenges such as the need for proper content design and the integration of VR into existing curricula.

Pantelidis, V. S. (2010) [8] explores the benefits of virtual reality (VR) in education, emphasizing its role in enhancing engagement, retention, and experiential learning. The study proposes a model for determining the suitability of VR based on content complexity and learning objectives, highlighting its effectiveness in providing immersive and interactive simulations. Additionally, the paper discusses the potential of VR in various educational contexts, including science and medical training, where traditional methods may fall short. It also addresses challenges such as cost, accessibility, and the need for specialized hardware, which must be considered when implementing VR in educational settings.

Rizzo, Buckwalter, Bowerly, et al. (2000) [9] developed the Virtual Classroom, a pioneering VR environment designed to assess and rehabilitate attention deficits. Their system integrates a head-mounted display with full-body tracking to simulate a realistic classroom setting—complete with a virtual teacher, desks, and controllable distractors like hallway noise and outside window activities. In testing both neurotypical children and those with ADHD, the platform enabled precise measurement of attentional responses under ecologically valid conditions. The study highlighted how VR's immersive, controlled scenarios offer improved engagement and ecological validity compared to traditional assessments. This work laid critical groundwork for subsequent VR-based interventions targeting attention and cognitive rehabilitation.

III. METHODOLOGY

A. Overview of the System

This project involves the development of an immersive virtual classroom environment using Unity3D, designed to simulate a realistic educational setting. Accessible through the Meta-Quest 2 headset, the system incorporates 3D classroom design, animated avatars, real-time interaction features, and multimedia presentation tools to enhance remote learning. The application enables users to join a virtual lobby, authenticate via a login system, and participate in live sessions where a teacher presents educational content using PowerPoint slides. The virtual space facilitates student engagement through voice and text-based communication, creating an interactive and structured classroom experience.

B. Development Environment and Tools

The development process began with setting up the necessary hardware and software infrastructure. Unity Hub and the Unity Editor (LTS version) served as the core development environment for building the application. The Oculus Integration package was used to enable VR support and interaction capabilities for the Meta-Quest 2 headset. The virtual classroom scene included a 3D model imported from Sketchfab to simulate a realistic classroom environment. A teacher avatar was created using Ready Player Me and animated using motion files from Mixamo to replicate lecture gestures and natural movements. To facilitate teaching, a PowerPoint presentation was embedded within the classroom. Real-time interaction features were implemented using Photon—enabling both chat and audio communication through a dedicated interaction panel. These tools together contributed to creating an immersive and interactive virtual classroom experience.

C. Scene Creation and Implementation

The virtual classroom environment was developed by integrating various assets, primarily sourced from Sketch-fab and the Unity Asset Store. The 3D classroom model was imported to serve as the central learning space. The overall scene flow includes the Start Scene, Lobby Scene, Login Scene, Classroom Scene, and Interaction Panel Scene. The Start Scene features a user-friendly introduction interface, guiding users into the virtual environment. The Lobby Scene acts as a transitional space, while the Login Scene manages user authentication and session handling. In the Classroom Scene, a teacher avatar—created using Ready Player Me and animated via Mixamo-delivers a PowerPoint presentation within a realistically modeled virtual classroom. To support interaction, the Interaction Panel Scene incorporates chat and audio functionalities powered by Photon, allowing students to engage in real-time communication. This structured multi-scene design ensures a seamless and immersive learning experience from entry to active participation.

D. Avatar Modeling and Animation

Avatar creation and animation play a key role in delivering an engaging classroom experience. A teacher avatar is generated using Ready Player Me to represent the instructor within the virtual environment. To enhance realism, the avatar is assigned an Animator Controller in Unity, and natural movement sequences are applied using animations sourced from Mixamo. These animations are synchronized with the presentation flow, making the teaching process appear more lifelike. The integration of animated avatars contributes to a more immersive and interactive atmosphere, helping students feel connected and attentive during the virtual sessions.

E. User Interaction and Interface Elements

User interaction within the virtual classroom is facilitated through the XR Origin Rig Camera setup, providing smooth integration with the Oculus Quest 2 headset. Navigation and interaction are handled using the Oculus Touch controllers, with the thumbstick enabling movement and buttons used to trigger scene transitions, such as entering the classroom from the lobby. The interaction panel includes real-time communication features implemented using Photon Chat for text messaging and Photon Voice for audio discussions. These interactive components allow students to actively participate in classroom activities, ask questions, and collaborate with peers, effectively replicating a real-world classroom experience in a virtual space.

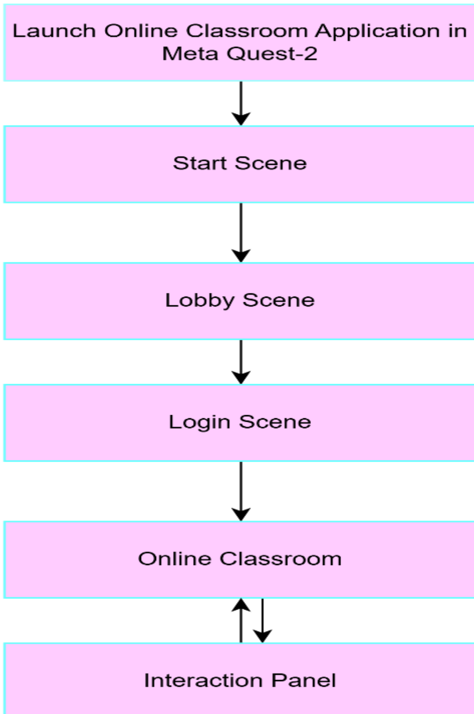

Fig.1 User Interaction

F. Script Execution

Several custom scripts are implemented to control user interaction, scene transitions, and multimedia functionality within the virtual classroom. The StartSceneManager.cs script handles navigation from the start scene to the lobby, while LobbyManager.cs manages user movement and interaction within the lobby environment. LoginManager.cs processes user login actions and transitions to the classroom scene. Within the classroom, SlideManager.cs facilitates navigation through PowerPoint slides during the lecture, allowing the teacher avatar to guide the session. Additionally, Photon integration scripts enable real-time communication through chat and audio features in the interaction panel, enhancing collaborative learning experiences. These scripts collectively ensure a seamless and interactive flow across different scenes in the virtual classroom.

G. Immersion Design and Application Implementation

Immersion is enhanced by using appropriate lighting, realistic textures, and background audio to create a classroom-like environment. A 3D model is used for displaying PowerPoint slides inside the virtual classroom to make the lecture more interactive. The slides are clearly visible to users within the VR space and are positioned to ensure comfortable viewing from various angles.

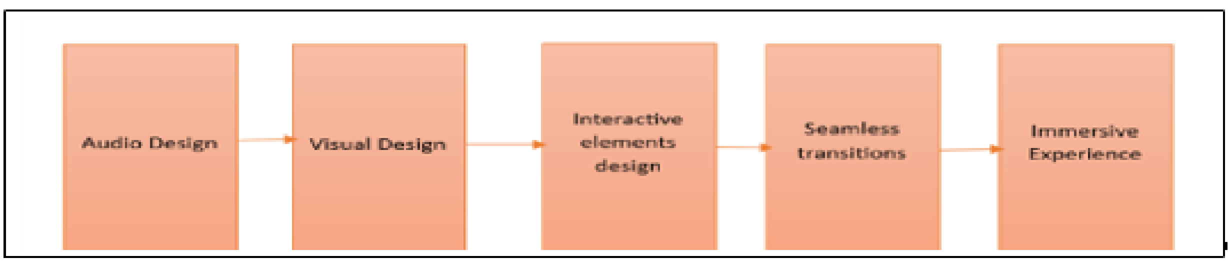

Fig.2 Immersion Enhancement Flowchart

IV. RESULTS

A virtual classroom application was developed using Unity3D and deployed on the Meta Quest 2 headset. The system includes multiple scenes—StartScene, LobbyScene, LoginScene,ClassroomScene, and InteractionPanelScene—with smooth transitions between each. Users begin at the Start Scene, where pressing the 'A' button on the Oculus controller navigates them to the Lobby and subsequently through login to the classroom environment. Inside the classroom, a teacher avatar delivers lessons using 3D PowerPoint slides, while students can interact using text and voice chat features integrated through Photon. Fig. 3 shows the Welcome Scene interface that welcomes the user into the virtual learning environment.

Fig 3. Welcome Scene

Fig. 4. Lobby Scene where the teacher creates a room by entering a room number and password. Students can join the session by selecting the "Join" option and entering the corresponding credentials. This lobby setup ensures organized session management by assigning each class a unique room number and password. It enables both teachers and students to join the same virtual session seamlessly.

The Application is deployed on the Meta Quest 2 headset, allowing users to navigate through different scenes such as the start menu, lobby, login, classroom, and interaction panel. This setup provides a smooth and interactive virtual learning experience. Interactive elements like real-time audio and chat features help simulate an actual classroom setting. Overall, the design focuses on creating an engaging and accessible educational environment through VR. The deployment ensures minimal latency and smooth user interaction throughout the session. This project lays a foundation for scalable virtual classrooms that can support diverse educational needs.

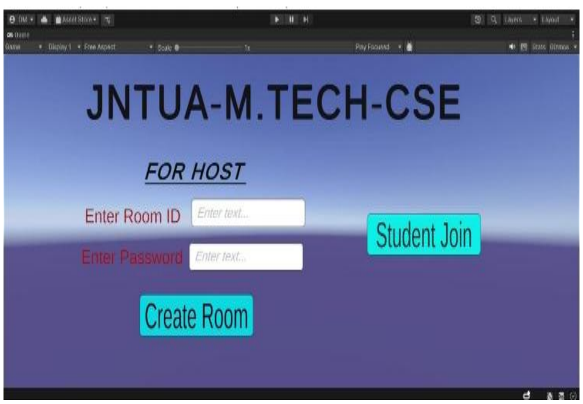

Fig 4. Lobby Scene

Fig. 5. Login Scene where users enter their username and credentials to access the virtual classroom. This ensures secure access and helps identify participants in the session.

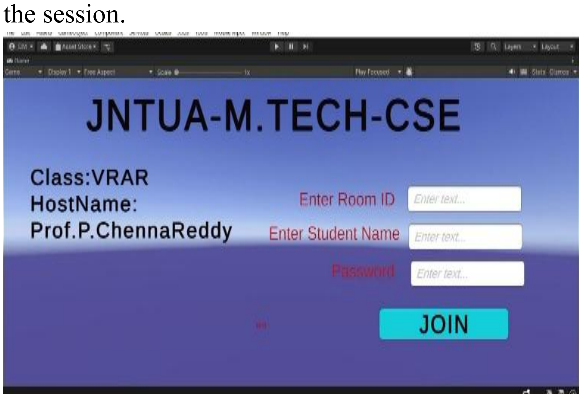

Fig 5. Login Scene

Fig. 6. Classroom Scene where the teacher avatar presents a PowerPoint lecture with animations. Users can navigate to the Interaction Panel using the provided option and return to continue the session.

Fig 6. Classroom Scene

Fig. 7. Interaction Panel Scene where students engage in real-time communication through integrated chat and audio features using Photon. The design allows seamless navigation between the classroom and interaction panel, ensuring continuous participation.

Fig 7. Interaction Panel

The virtual classroom application demonstrates smooth scene transitions and effective user interaction using the Oculus Quest 2. Each component—from login to live classroom interaction—works cohesively to simulate an immersive and engaging educational environment.

V. CONCLUSIONS

The development of a virtual classroom using Unity3D and the Meta-Quest 2 headset successfully creates an immersive and interactive learning environment. Real-time communication is facilitated through text-based chat, Photon Chat, and Photon Audio, enabling seamless interaction between students and instructors. The integration of VR technology enhances the remote learning experience, bridging the gap between physical and virtual classrooms. The Meta-Quest 2 headset further enriches student engagement, providing a more realistic and immersive environment. The project demonstrates the potential of VR to transform online education, offering a solution that enhances participation and overcomes geographical barriers. The findings highlight the effectiveness of VR-based education and suggest opportunities for further advancements in virtual learning environments. These outcomes support the continued exploration of immersive technologies in education to improve accessibility and learner involvement.

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