BEYOND BOUNDARIES: ENGINEERING JOURNEYS IN RURAL COMMUNITIES THROUGH XR

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Abstract **—Traditional career exploration methods in engineering often fail to provide the immersive and dynamic experiences necessary for students to make well-informed decisions about their future careers. This research paper presents the "Engineering Journeys" project, which aims to bridge this gap by leveraging virtual reality (VR) and artificial intelligence (AI) technologies. The project involves designing and developing a VR-based application allowing students to explore various engineering disciplines interactively. Using Blender for 3D model creation and Unity3D for implementation, the application integrates ConvoAI to provide an AI-driven virtual teacher. This AI component is trained to answer queries about different engineering branches, helping students better understand their options. The application is built to offer an immersive, user-friendly experience, providing visualizations and simulations of engineering scenarios. Initial feedback from students indicates a significant improvement in their understanding and confidence in making career choices. This innovative approach demonstrates the potential of VR and AI in transforming educational methods and aiding students in rural communities.**

Keywords: Virtual Reality (VR), Artificial Intelligence (AI), Career Exploration, Engineering Education, 3D Modeling, Blender, Unity3D, ConvoAI, Immersive Learning, Rural Communities, Educational Technology, Interactive Learning, Student Decision-Making, Engineering Disciplines, VR Applications.

I. INTRODUCTION

In today's fast-paced and technology-driven world, choosing the right career path is more critical than ever. However, traditional methods of career exploration in engineering often fall short of providing the necessary dynamism and engagement required to help students make informed decisions. This is particularly true for students in rural communities, where access to resources and guidance is limited. As a result, many students end up making career choices without a clear understanding of what each engineering discipline entails, leading to dissatisfaction and potential career changes later in life

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The "Engineering Journeys" project was conceived to address this significant gap by leveraging the latest advancements in virtual reality (VR) and artificial intelligence (AI) technologies. The primary objective is to create an immersive, interactive VR application that enables students to explore various engineering fields in a way that traditional methods cannot match. By providing a virtual environment where students can interact with 3D models of engineering tools and scenarios, this project aims to bring engineering education to life.

The core of this project involves the integration of AI to enhance the learning experience further. Using ConvoAI, an advanced conversational AI platform, I have developed a virtual teacher capable of answering students' queries related to different engineering branches. This AI-driven component ensures that students receive accurate, comprehensive information, helping them make better-informed decisions about their future careers.

To develop this application, I employed a range of cutting-edge technologies. Blender was used for the creation of detailed 3D models, providing realistic and engaging visual representations of various engineering tools and environments. These models were then implemented in Unity3D, a powerful game engine that supports VR development, allowing for a seamless and immersive user experience. The ConvoAI platform was integrated into Unity to create an interactive and intelligent virtual teacher, providing real-time responses to students' questions.

This innovative approach has the potential to revolutionize the way students explore and choose their career paths, particularly in rural areas where traditional resources may be scarce. Initial feedback from students has been overwhelmingly positive, indicating a marked improvement in their understanding and confidence in making career choices.

II. LITERATURE SURVEY

1. **Learning Analytics in VR Classrooms**
   Lin ShengKai et al. (2023) investigates the potential of collecting learning logs within VR classrooms. Their study highlights the use of eye tracking and other analytics to provide insights into student engagement and learning patterns. This approach can significantly enhance the effectiveness of VR-based learning environments by allowing educators to tailor their methods based on real-time data collected during VR sessions.

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2. **VR in Virtual Intelligent English Teaching**

   Qu Hui (2023) presents a method for distance education in English reading using VR technology. The study constructs a virtual experiment platform and proposes an interactive education method based on conflict detection.

3. **Metaverse in Education**

   Arman Raj et al. (2023) delve into the concept of the metaverse and its application in Education 4.0. They discuss how the metaverse can provide a comprehensive and interactive learning experience, enabling real-time interaction with digital artifacts. The detailed framework presented in this paper is crucial for understanding how VR can be expanded to create a fully immersive educational environment.

4. **Visual Analysis of Extended Reality in Education**

   Yan Yi et al. (2023) use CiteSpace to analyze the application of extended reality (XR) in education. Their study identifies research trends, influential authors, institutions, and highly cited literature. This meta-analysis helps in understanding the current landscape of XR in education and identifies key areas of focus and innovation.

5. **Designing VR Classrooms with Kansei Engineering**

   Keiya Maruko et al. (2023) explore the design of VR classrooms using Kansei engineering analysis. Their research emphasizes creating an environment conducive to concentration and effective learning through VR technology. This study is particularly relevant for designing VR applications that aim to provide an engaging and focused educational experience.

6. **Cognitive Engagement in Collaborative VR Activities**

   Isaac D. Dunmoye et al. (2023) investigate cognitive engagement in collaborative VR statics activities. Utilizing the ICAP framework, they assess how VR can enhance student interaction and learning outcomes in collaborative settings. This research highlights the importance of designing VR activities that promote active and engaged learning.

7. **Enhancing Student Engagement through VR**

   Dinesh Bhatia and Henrik Hesse (2023) conducted a survey-based analysis of the impact of VR on student engagement in engineering education. Their findings indicate that VR has the potential to significantly enhance student learning experiences by providing interactive and immersive environments. This paper supports the idea that VR can make engineering education more appealing and effective.

8. Soft Skill Development with ChatGPT and VR

K. Sai Nihal et al. (2023) explore the use of ChatGPT and VR to enhance soft skill development. The study emphasizes the role of VR in providing realistic training scenarios and helping students and employees develop essential soft skills through immersive experiences. This approach can be integrated into engineering education to improve both technical and non-technical skills.

9. Robotics and Competition-Integrated Teaching

Yu Jiang et al. (2023) discuss the integration of robotics into education through competition-based learning. Their research shows that combining hands-on robotics projects with VR can prepare students for real-world engineering challenges, fostering innovation and practical skills.

10. Optimization of VR Video Wireless Transmission

Isaac D. Dunmoye et al. (2023) address the challenges of VR video transmission. They propose an architecture that enhances performance through view prediction and coding technologies. This optimization is crucial for ensuring a smooth and immersive VR experience, which is essential for educational applications.

III. METHODOLOGY

1. Research on Engineering Students' Challenges

Objective: To identify the challenges faced by students when choosing an engineering domain post-12th standard.

Surveys and Interviews: Conducted detailed surveys and interviews with current engineering students, recent graduates, and educators to gather qualitative and quantitative data on the difficulties encountered during career selection.

Literature Review: Reviewed existing studies and reports on career guidance and decision-making processes in engineering education to identify common themes and gaps.

Data Analysis: Analyzed the collected data to pinpoint specific areas where students lack information or resources, and to understand the factors influencing their career decisions.

2. 3D Model Creation in Blender

Objective: To create realistic and engaging 3D models of engineering tools, environments, and scenarios.

Selection of Models: Based on the research findings, selected key engineering tools and environments that are critical for understanding various engineering disciplines.

Modeling Process: Utilized Blender, an open-source 3D modeling software, to create detailed and accurate models. The process involved:

Blueprint Collection: Gathered blueprints and reference images to ensure accuracy.

Modeling: Created the basic shapes and structures using Blender's modeling tools.

Texturing and Lighting: Applied textures and lighting to enhance realism.

Optimization: Ensured models were optimized for performance in VR environments by reducing polygon count and using efficient textures.

3. **Implementation of 3D Models in Unity3D**

Objective: To integrate the 3D models into a functional VR application using Unity3D.

Scene Setup: Created scenes in Unity3D to represent various engineering environments and scenarios.

Model Import: Imported the 3D models from Blender into Unity3D, ensuring compatibility and performance optimization.

Interactivity: Added interactive elements such as clickable objects, animations, and informational overlays to make the VR experience engaging and educational.

User Interface (UI) Design: Developed a user-friendly interface to guide students through the VR environment, incorporating menus, tooltips, and navigation aids.

4. **4. Integration of ConvoAI with Unity**

Objective: To provide an AI-driven virtual teacher capable of answering students' queries about engineering disciplines.

AI Training: Used ConvoAI to train the virtual teacher on a comprehensive dataset covering various engineering branches. The dataset included information on course content, career prospects, and industry requirements.

API Integration: Integrated ConvoAI with Unity using the provided plugin, enabling real-time interaction between the virtual teacher and the students.

Testing: Conducted extensive testing to ensure the AI could understand and respond accurately to a wide range of student queries. Iteratively improved the AI responses based on feedback and testing outcomes.

5. **Development for VR Platforms**

Objective: To build and deploy the VR application for use on multiple VR platforms.

Platform Selection: Choose VR platforms that are widely accessible and compatible with the developed application, such as Oculus, and Meta Quest.

VR Optimization: Optimized the application for VR performance, ensuring smooth interactions, minimal latency, and high frame rates.

Rendering Optimization: Adjusting rendering settings to balance performance and visual quality.

Input Handling: Configuring VR controllers and input mechanisms to enhance user interaction.

IV. SYSTEM DESIGN AND ARCHITECTURE

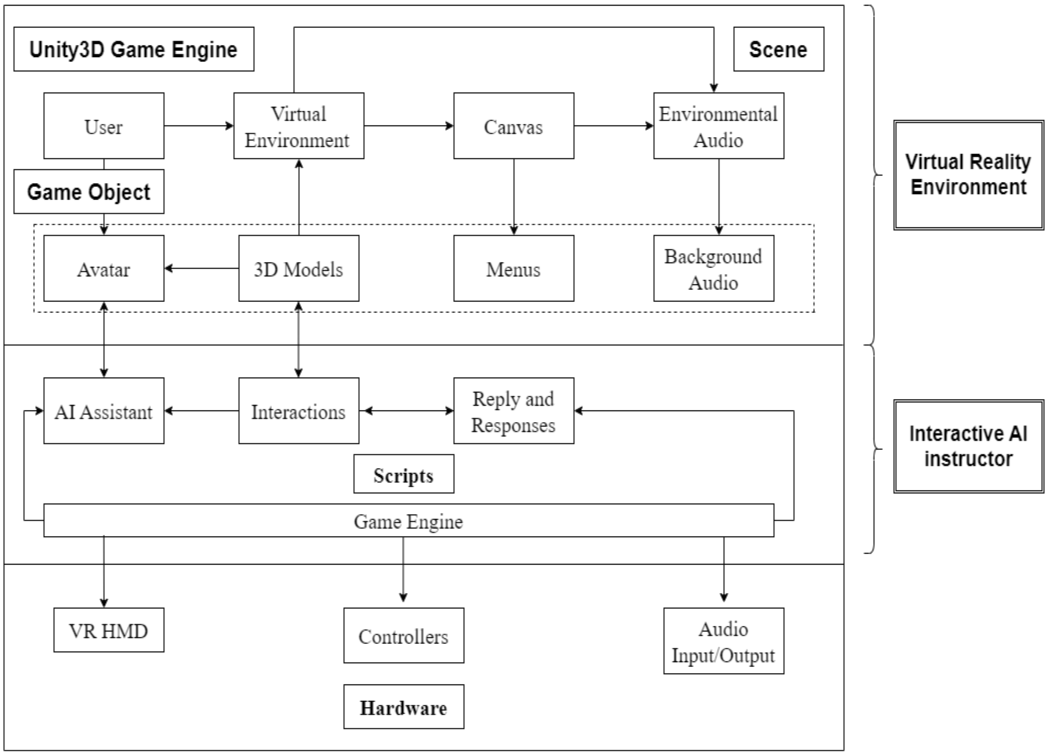

Fig 1 Architectural diagram

- **Unity3D Game Engine:** Core framework for the VR application.
- **User:** The person interacting with the VR environment.
- **Virtual Environment:** The immersive world within the VR application.
- **Game Objects:** Includes avatars, 3D models, menus, AI assistants, interactions, and AI responses.
- **Scene:** Comprises environmental and background audio, and canvas layouts.
- **Virtual Reality Environment:** The overall immersive world created for educational purposes.
- **Interactive AI Instructor:** The AI system that guides and educates users.
- **Hardware:** VR headsets (HMD), controllers, and audio input/output devices.

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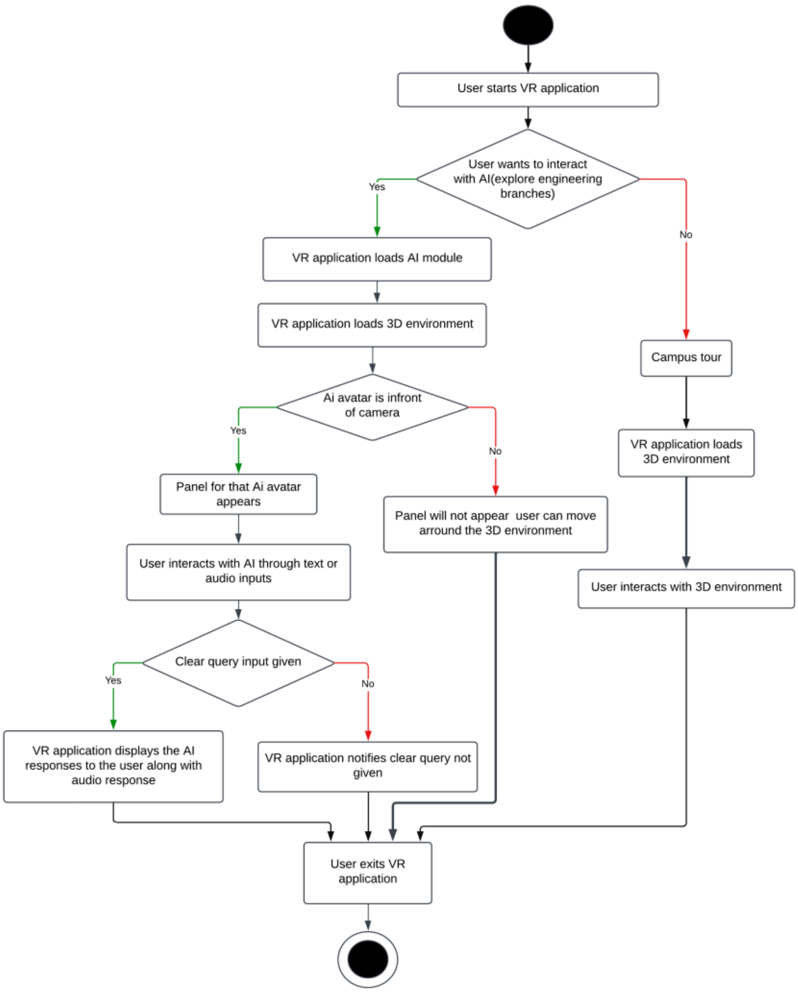

Fig 2 Activity diagram

- **Start Application**: The user starts the VR application.
- **Display Main Menu:** The application displays the main menu.
- **Choose Interaction Type:** The user selects whether to interact with AI/explore engineering branches or take a campus tour.
- **Load AI Module Decision:** The application checks the user's choice.
- **Load AI Module:** If the user selects AI interaction, the application loads the AI module.
- **Load 3D Environment:** The VR application loads the relevant 3D environment.
- **Position AI Avatar:** The AI avatar is positioned in front of the camera.
- **Display AI Panel:** A panel for AI avatar interaction appears.
- **User Interacts with AI:** The user begins interacting with the AI via text or audio inputs.
- **Process User Input:** The application processes the user’s text or audio input.

- **Check Query Clarity:** The application checks if the user's query input is clear.
- **Respond to Query:** If the query is clear, proceed to respond. If not clear, notify the user.
- **Display AI Response:** The application displays the AI's responses and plays the corresponding audio.
- **Additional Queries:** The user can input additional queries if desired.
- **End AI Interaction:** The user decides to end the interaction with AI.
- **Exit AI Module:** The user exits the AI module.
- **Explore 3D Environment:** If the user chooses the campus tour, the application loads the 3D environment without the AI module, allowing free exploration.
- **Exit Application:** The user decides to exit the VR application and completes the session.

V. IMPLEMENTATION

1. Creation of 3D Models Using Blender

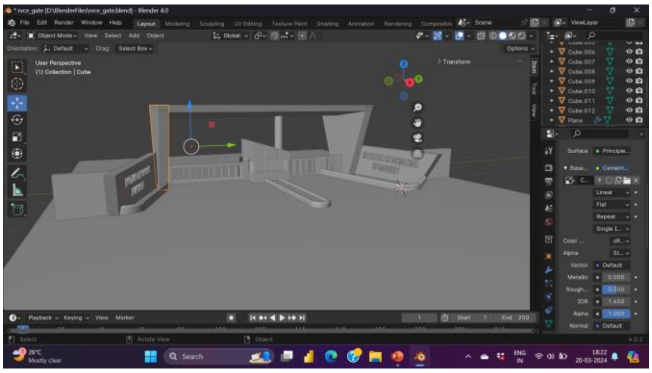

Fig 3 3D Model Creation

The first step in the implementation process is the creation of detailed 3D models using Blender. Blender, a powerful open-source 3D modeling software, allows for the design of realistic and intricate models that represent various engineering tools, environments, and scenarios. The modeling process involves

Modeling: Building the basic shapes and structures of the models.

Texturing: Applying textures to give the models a realistic appearance.

Lighting: Adding appropriate lighting to enhance the visual quality.

Optimization: Ensuring that the models are optimized for performance in a VR environment by reducing polygon count and using efficient textures.

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2. Creation of College Scenario/Environment in Unity Scene

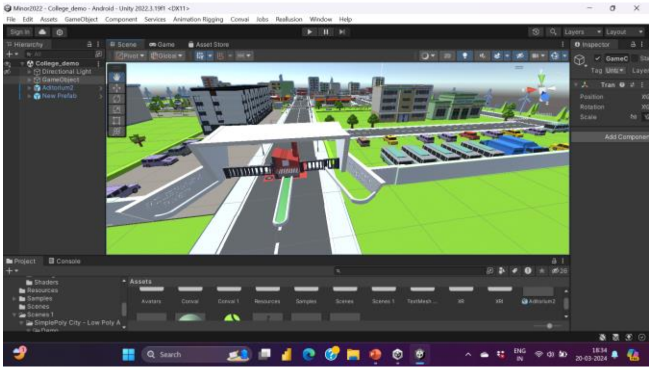

Fig 4 Unity Game Engine

Once the 3D models are ready, the next step is to create a realistic and immersive college scenario within Unity. This involves

Scene Setup: Setting up the Unity scene to represent various areas of a college campus, including classrooms, laboratories, and common areas.

Model Integration: Implementing the 3D models created in Blender into the Unity scene, placing them in appropriate locations to create a cohesive environment.

Interactivity: Adding interactive elements such as clickable objects, animations, and informational overlays to enhance user engagement.

3. Implementation of ConvoAI for AI-Driven Lecturer

Fig 5 Convo AI Assistant

To provide an interactive learning experience, the project integrates ConvoAI, an AI-driven lecturer who can answer students' queries about engineering disciplines. This step involves

AI Training: Training the AI with comprehensive data on various engineering branches, including course content, career prospects, and industry requirements.

Unity Integration: Using the ConvoAI plugin to integrate the AI-driven lecturer into the Unity environment, enabling real-time interaction between the virtual teacher and the students.

Testing and Refinement: Conduct extensive testing to ensure the AI responds accurately to a wide range of queries, followed by iterative refinement based on feedback

4. Integration of Query Panel

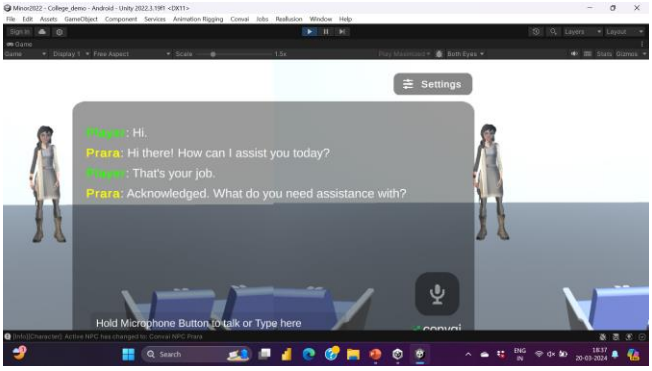

Fig 6 Convo AI Query Panel

The final step in the implementation phase is the integration of a query panel that allows students to interact with the AI-driven lecturer. This involves

UI Design: The query panel is designed to be user-friendly and seamlessly integrated into the VR environment. This involves creating a layout that is intuitive and visually appealing, ensuring that all users can easily navigate and interact with the panel. Clear input fields and distinct, easy-to-press buttons are included to facilitate straightforward usage. Accessibility is a priority, so the design accommodates a wide range of users, including those with varying levels of technological proficiency.

Functionality: The core functionality of the query panel focuses on enabling students to ask questions either by typing or speaking. The AI responds quickly with accurate, contextually relevant answers. To enhance the user experience, the panel supports advanced features like voice recognition and auto-suggestions. These features are designed to make interactions smoother and more efficient, helping students get the information they need with minimal effort

Testing: Thoroughly testing the query panel to ensure it runs smoothly within the VR environment. This involves getting feedback from different users, fixing any issues, and making sure it works well with various VR devices. We'll keep improving it based on what users say.

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VI. TESTING

Testing: Thoroughly testing the query panel to ensure it runs smoothly within the VR environment. This involves getting feedback from different users, fixing any issues, and making sure it works well with various VR devices. We'll keep improving it based on what users say.

Testing ID	Feature Tested	Sample Input	Expected Output	Actual Output	Remarks
TC01	Navigation and interaction	The user navigates through a VR environment	Seamless navigation, interactive virtual scenes	As expected	Pass
TC02	Rendering techniques	User explores 3D models	Realistic rendering, smooth interactions	As expected	Pass
TC03	Scenario simulation	The user engages in simulated scenarios	Immersive experience, scenario accuracy	As expected	Pass
TC04	Dizziness sensation	The user wears HMD for an extended period	No dizziness, comfortable VR experience	No discomfort reported	Pass
TC05	Vomiting sensation	User experiences VR for a prolonged time	No nausea or vomiting sensation	No discomfort reported	Pass

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VII. RESULTS AND DISCUSSIONS

In our project, we implemented a virtual reality (VR) scenario designed to offer users an immersive campus tour experience of an engineering college. This VR simulation allows users to navigate through different areas of the campus, providing a comprehensive exploration of the college environment. By leveraging VR technology, prospective students can virtually explore the campus layout and facilities, gaining a realistic preview that aids in their decision-making process regarding their educational path.

Immersive Campus Exploration

The VR-enabled campus tour offers a dynamic and interactive experience

Navigational Freedom: Users can freely navigate through key campus locations such as classrooms, laboratories, and communal areas.

Visual Realism: The VR simulation replicates the real-world campus environment with high fidelity, showcasing architectural details and spatial arrangements.

Interactive Elements: Interactive features within the VR environment allow users to interact with objects, view informative overlays, and learn about specific facilities and resources available.

Enhancing Decision-Making

The incorporation of VR for campus tours contributes significantly to informed decision-making

Realistic Preview: Prospective students can virtually explore the campus before physically visiting, helping them envision themselves within the college environment.

Facilities Assessment: Users can assess the quality and suitability of campus facilities, including laboratories, libraries, and recreational spaces.

Educational Environment: The immersive experience provides insights into the educational atmosphere and community, influencing prospective students' perceptions and choices.

Comparative Advantages

Compared to traditional methods of campus tours

Accessibility and Convenience: VR tours offer accessibility to prospective students regardless of geographical location or travel constraints.

Interactive Engagement: VR provides a more engaging and memorable experience than static images or videos, fostering deeper connections with the campus environment.

Personalized Exploration: Users can customize their exploration based on interests, focusing on areas

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relevant to their academic and personal preferences.

Educational Impact

The VR campus tour exemplifies the transformative potential of immersive technologies in education

Innovative Learning Tools: Integrating VR enhances educational experiences by providing innovative tools for campus exploration and student engagement.

Future Applications: Insights gained from this project contribute to future developments in educational VR applications, influencing advancements in virtual campus tours and career exploration tools.

VIII. CONCLUSION

In conclusion, our project showcases the transformative potential of virtual reality (VR) technology in engineering education and career exploration. Through innovative features like the VR campus tour and interactive AI instructor, we have created an immersive and personalized learning environment. This environment empowers users to explore engineering concepts and pathways dynamically, enhancing engagement and retention of educational content. The VR campus tour enables prospective students to remotely explore campus facilities and environments, offering a comprehensive understanding of the educational institution before making commitments. Moreover, interactive experiences with AI-driven instructors allow users to clarify doubts and receive personalized guidance, fostering informed decisions about their academic and professional futures.

This project underscores the capacity of VR and AI technologies to revolutionize educational experiences by tailoring content to individual learning styles and preferences. It also overcomes geographical barriers, granting access to educational resources and experiences that traditional methods cannot provide. As a catalyst for educational innovation, VR promotes new teaching methodologies and learning paradigms that enrich educational outcomes and prepare students for future challenges in engineering and beyond.

Looking forward, the successful implementation of VR in engineering education sets the stage for continuous advancements in educational technology. These advancements will refine and expand educational applications, improving learning outcomes across disciplines. The insights gained from our project contribute to ongoing research in educational technology, guiding future initiatives aimed at enhancing learning experiences and student engagement. By bridging academia and industry, VR prepares students with practical skills essential for succeeding in engineering careers amidst technological advancements.

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