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Enhancing Engineering Education in the Roblox Metaverse: Utilizing chatGPT for Game Development for Electrical Machine Course

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***Abstract*—This research paper explores the use of chatGPT to facilitate the development of educational experiences in the Roblox metaverse, specifically focusing on the electrical machine course. The primary objectives of this study are to demonstrate how chatGPT can streamline the creation of immersive and interactive learning environments within Roblox and to evaluate the efficacy of these experiences in engaging students and enhancing their understanding of electrical machines. Our approach leverages chatGPT's capabilities to optimize client-side scripts for server-side implementation efficiently, create well-structured dictionaries for describing game activities, stages, and points, and simplify the implementation of various effects and interactions. Upon completing our Roblox-based educational experience, the resulting code will be available under a Creative Commons license, allowing other educators and developers to build upon and customize our work for their needs. We tested this project with a group of 22 college-level students studying electrical machines, whose feedback has been instrumental in understanding the effectiveness of our methods and identifying areas for improvement. The results of this study suggest that integrating chatGPT into the development process of Roblox-based electrical machine-learning experiences can lead to increased student engagement and understanding. Further research is recommended to explore the broader implications of using chatGPT and other AI-powered tools in developing metaverse-based educational content across various subjects and learning environments. By doing so, we can continue to push the boundaries of what is possible in virtual education and provide more engaging and effective learning experiences for students worldwide.**

***Keywords*—Roblox; chatGPT; electrical machine; game-based learning.**

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I. INTRODUCTION

The metaverse, an interconnected, immersive virtual world, has grown significantly in recent years, offering new opportunities for social interaction, entertainment, and education. As a digital universe transcending traditional online environments' boundaries, the metaverse has emerged as a promising platform for educational purposes, particularly in engineering. With the potential to create realistic, interactive learning experiences, the metaverse can revolutionize how students understand complex concepts and engage with engineering topics, including electrical machines.

The introduction of chatGPT, an advanced language model developed by OpenAI, presents an opportunity to enhance the educational potential of the metaverse. chatGPT's ability to understand natural language and generate contextually relevant responses has been leveraged in various domains, from customer support to content creation. This research paper explores how chatGPT can be a valuable tool to facilitate interactive learning experiences in the metaverse, streamlining the development process and making educational content more accessible.

In engineering, education has traditionally relied on lectures, textbooks, and laboratory experiments to teach complex topics, such as electrical machines. However, these methods often need to be more engaging for students and foster a deep understanding of the subject matter. With its immersive and interactive capabilities, the metaverse can address these shortcomings by providing hands-on, experiential learning opportunities catering to various learning styles.

The role of chatGPT in this context extends beyond simply providing information to students. Educators can easily create more engaging and interactive learning environments by integrating chatGPT into the development process of metaverse-based educational experiences. The ability of chatGPT to optimize the code, develop well-structured dictionaries to describe game activities, stages, and points, and implement various effects and interactions can prove invaluable in creating educational content in the metaverse.

This paper aims to explore the potential of chatGPT in facilitating interactive learning experiences in the Roblox metaverse, focusing specifically on electrical machine education. By examining the effectiveness of these learning experiences in engaging students and enhancing their understanding of electrical machines, we hope to shed light on the implications of using AI-powered tools like chatGPT in developing metaverse-based educational content.

The primary purpose of this study is to investigate the potential of using chatGPT as a tool for developing interactive and engaging educational experiences in the Roblox metaverse, specifically in the context of electrical machine education. By examining the implementation and outcomes of a metaverse-based learning environment enriched with chatGPT, the study aims to provide valuable insights into the effectiveness of such an approach in enhancing students' understanding of complex engineering concepts. The scope of the study is limited to the design and development of the educational experiences within the Roblox metaverse and the evaluation of their impact on student learning.

The research questions and objectives of the study are as follows:

- How can chatGPT be effectively utilized in developing metaverse-based educational experiences for electrical machine education in the Roblox platform?
- What is the impact of chatGPT-enhanced educational experiences on students' engagement and understanding of electrical machines?
- What are the challenges and limitations of integrating chatGPT into developing metaverse-based educational content for electrical machine education?
- How can the findings of this study contribute to the broader understanding of AI-enhanced metaverse-based education in the engineering field?

By addressing these research questions and objectives, the study aims to contribute to the growing body of knowledge on AI-enhanced metaverse education and offer practical guidance for educators and developers seeking to leverage the capabilities of tools like chatGPT in creating effective and engaging learning experiences, particularly in the engineering field.

II. Materials and Methods

A. Overview of Technologies

In this study, we have utilized a virtual learning environment within the metaverse to teach electrical machine topics. The metaverse, a collective virtual shared space, has gained significant attention recently for its potential to revolutionize various aspects of life, including education [1]–[4]. By creating an immersive platform for users to interact with one another and engage in various activities, the metaverse offers unique opportunities for enhanced learning experiences [5]–[7].

Roblox, a popular platform within the metaverse, was chosen for its user-friendly interface, extensive developer support, and customizable features [8]–[10]. The platform has been recognized for its potential to facilitate interactive learning and foster collaboration and creativity among students [11]–[13]. Roblox, a leading platform in the metaverse, has garnered significant popularity due to its accessible and user-friendly interface, enabling users to create, share, and engage with various virtual experiences. With millions of active users worldwide, Roblox provides a vast ecosystem of games and experiences developed by its user community, fostering creativity and collaboration among participants. As a highly customizable platform, Roblox offers a unique opportunity to develop immersive and interactive educational experiences that can be tailored to specific learning objectives and contexts.

In this study, we leverage the potential of Roblox to create an engaging virtual learning environment for electrical machine education, to enhance students' understanding and engagement with the subject matter. One key feature that sets Roblox apart as a platform for metaverse-based experiences is its powerful and flexible scripting capabilities.

Utilizing a scripting language called Lua, Roblox allows developers to create custom game mechanics, interactive objects, and other elements within their virtual environments. This programmability enables the development of tailored educational experiences that adapt to specific learning needs and objectives. In the context of our study, the Roblox scripting system was instrumental in designing interactive and immersive electrical machine learning experiences, offering students an engaging and hands-on educational platform that promotes a deep understanding of complex engineering concepts.

chatGPT, developed by OpenAI, excels at understanding natural language and generating contextually relevant responses. Its adaptability and AI-based nature make it a versatile and resource-effective tool for various applications. ChatGPT has played a vital role in Roblox script development, assisting in code planning, optimization, and function implementation in this project. By leveraging chatGPT's capabilities, the metaverse-based learning environment for electrical machines has been significantly enhanced, offering students a more interactive and engaging educational experience.

Blender, a powerful open-source 3D modeling and animation software, was used to create electrical machine parts for the virtual learning environment [14],[15],[16]. Blender scripting, which employs Python to automate tasks, create custom tools, and generate 3D models programmatically, was utilized to design and develop electrical machine components with increased efficiency, precision, and customization [17]–[19]. Fig.1 and Fig. 2 show the DC machine component parts created using Blender.

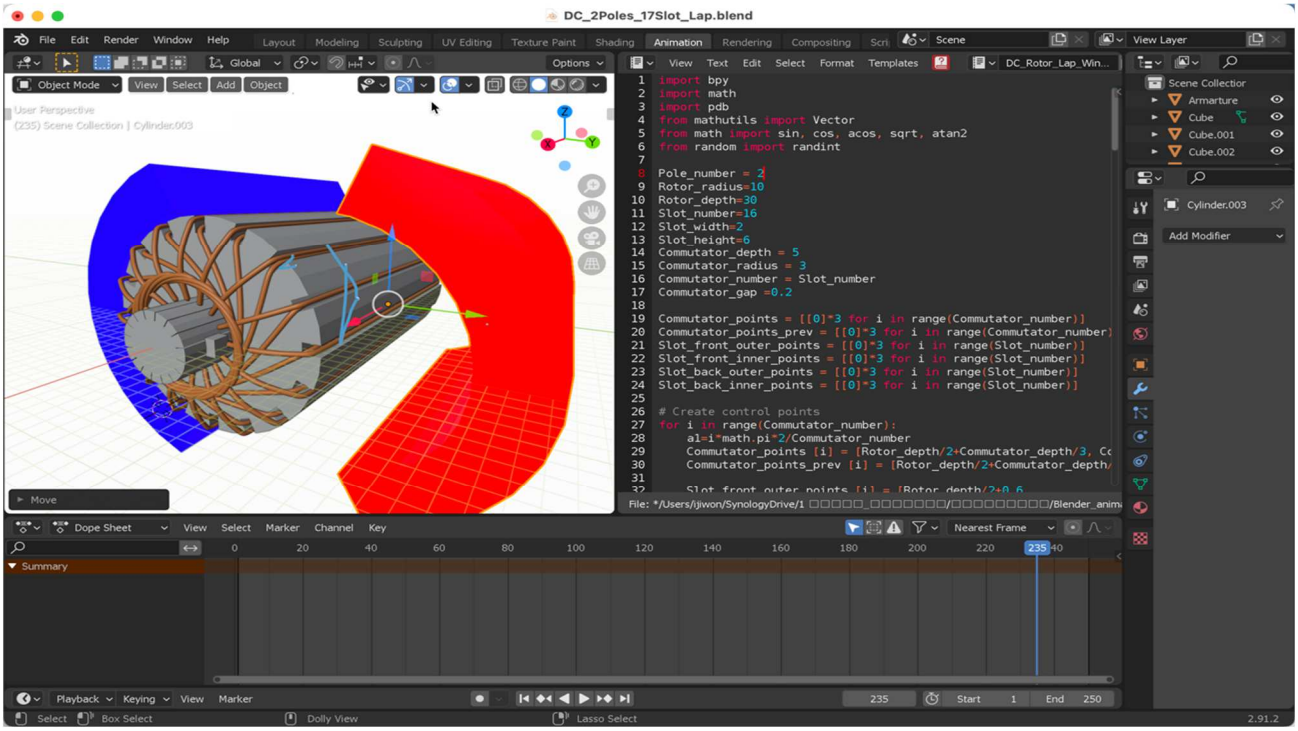

Fig. 1 Blender GUI

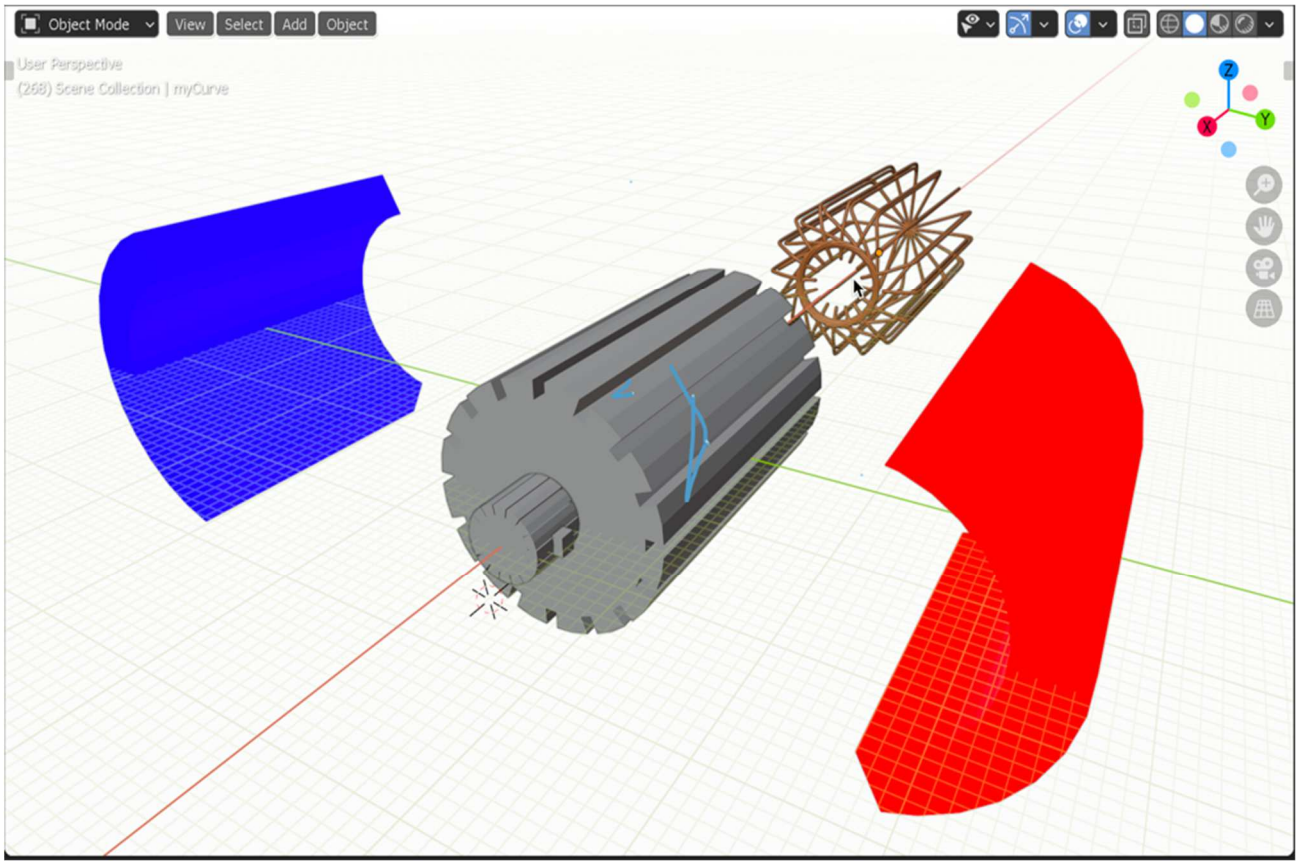

Fig. 2 DC machine created by Blender

B. *Development Process*

The development process involved several stages, including:

- Designing electrical machine parts using Blender and Blender scripting: Custom scripts and algorithms were implemented to generate accurate and detailed 3D models of electrical machine components.
- Importing the electrical machine parts into Roblox: The 3D models created in Blender were imported onto the Roblox platform, with necessary adjustments and optimizations to ensure compatibility.

- Integrating chatGPT into the game development stage: chatGPT was used to transform client-side scripts to server-side scripts, define game activities and stages, and facilitate the implementation of visual effects. The client-side scripts were developed without the aid of chatGPT previously.
- Building the virtual learning environment: The virtual environment was developed within Roblox, incorporating the electrical machine components, game activities, and visual effects to create an engaging and interactive learning experience [20]–[22].
- Testing and refining the virtual learning environment: The learning environment was tested and refined based on user feedback, ensuring a seamless and practical educational experience for students [23]–[25].

This research project demonstrates the potential of leveraging advanced tools like Blender, chatGPT, and the metaverse to create engaging and interactive educational experiences, particularly in engineering [26]–[30].

C. Game Structure and Design

The virtual learning environment, shown in Fig. 3, was designed with a modular and extendable structure, incorporating points, status, and stages to facilitate various activities. The game's structure incorporated different learning scenarios and topics while maintaining a cohesive learning experience.

Fig. 3 Roblox game in action

The game's initial development took approximately one month, during which the client-side scripting was employed in Roblox without using chatGPT. However, this approach made extending the game and modifying its story or scenario difficult, as individual scripts had to be created and managed for each part on the client-side.

To address this issue, we turned to chatGPT to transform the game's structure from client-side to server-side scripting, allowing for more flexibility and extensibility in the game's design. To transition the game from client-side to server-side scripting, we followed chatGPT's recommendation to generate server-side scripts to manage the game's activities, stages, and points. This approach made changing the game's story or scenario easier and allowed for more efficient management of the game's content by describing game activity on the server side rather than scripting into each client part. Examples of the code transformation can be seen in Fig. 4 and Fig. 5.

```
-- Client-side script
local part = workspace.Part
part.Touched:Connect(function()
    -- Perform some action
end)
```

Fig. 4 A sample of Roblox client-side script

```
-- Server-side script with ChatGPT assistance
local part = workspace.Part
local function handleTouch(hit)
    -- Perform some action
end
part.Touched:Connect(handleTouch)
```

Fig. 5 A sample of Roblox server-side script

In addition to facilitating the transition to server-side scripting, chatGPT was instrumental in creating a flexible scenario for the game by generating well-structured dictionaries that described the game's activities, stages, and points. This declaration made modifying the game's structure and adding new activities easier without extensive reprogramming. This dictionary structure was obtained by giving the command to chatGPT "Make a dictionary structure, which has stages. Each stage has a name and order list of parts to deal with, and points limit to pass to the next stage. Activity property is defined for each part about activity name, wrong and right answer response, points to get and lose when right/wrong response occurs". This command created the code like Fig. 6.

```
local stages = {
  {
    stageNumber = 1,
    order = {"DC_Field", "DC_Commutator", "DC_Brush","DC_Armature"},
    pointsRequired = 5, --40,
    activities = {
      DC_Field = {
        activityType = "touch",
        pointsIncrease = 10,
        pointsDecrease = 5,
        correctResponse = "Congratulation. Touch the commutator now!",
        wrongResponse = "You are wrong. This is DC field."},
      DC_Commutator = {
        activityType = "touch",
        pointsIncrease = 10,
```

Fig. 6 A dictionary game scenario declaration

chatGPT also aided in implementing various visual effects, such as fire and tweening. chatGPT helped streamline the development process and enhance the game's visual appeal by providing code snippets and guidance on incorporating these effects. An example of the code for implementing a fire effect is shown below, which is generated by giving the command "Insert code that the user answers correctly, make an effect that some fire flaming from user's body". This command created the code like Fig. 7.

```
-- Creating a fire effect with ChatGPT assistance
local fire = Instance.new("Fire")
fire.Parent = workspace.Part
fire.Size = 5
fire.Heat = 10
```

Fig. 7 A special effect code created by chatGPT

By leveraging chatGPT's capabilities, the development process became more efficient, and the resulting game was more adaptable and engaging for students.

D. Final Game Implementation

The final game implementation consists of three stages, each focusing on a different interaction with the electrical machine parts: touching, clicking, and restoring. These stages were designed to create an engaging and immersive learning experience for students. Below is a brief overview of each stage and its related activities.

1) Stage 1: Touching Electrical Machine Parts In the first stage, students are introduced to various electrical machine parts scattered throughout the virtual environment. The objective is to familiarize students with the components and their functions, and students interact with these parts by physically touching them within the virtual environment. Screen captures illustrating this stage will showcase the parts in the field and the students' avatars interacting with them, as in Fig. 8.

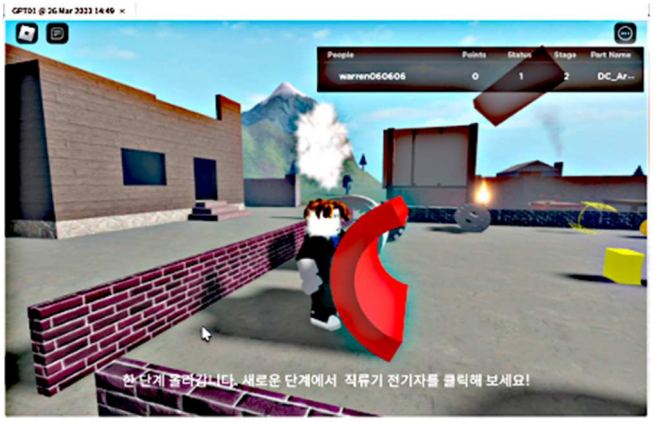

Fig. 8 Stage 1 with touch activity

2) Stage 2: Clicking Parts with Ladders In the second stage, an assembled DC machine is presented to the students. Using ladders, students need to click on the individual components of the machine to learn more about their roles in the overall assembly. This stage emphasizes understanding the machine's structure and how the parts work together. Screen captures will illustrate students using ladders to interact with the large DC machine and the various components being highlighted as they are clicked, as in Fig 9.

Fig. 9 Stage 2 with click activity

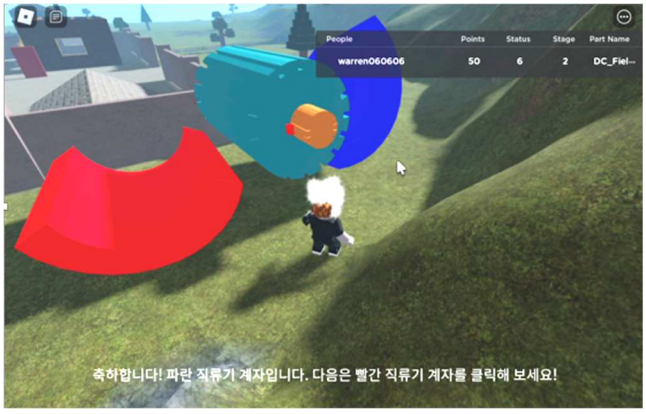

Fig. 10 Stage 3 with restore activity

3) Stage 3: Restoring Scattered Parts The third and final stage involves restoring scattered electrical machine parts to their prescribed positions. Students must select and place the parts correctly within the virtual environment. This stage reinforces the student's understanding of the assembly's machine components, functions, and relative positions. Screen captures will demonstrate the scattered parts and the students' avatars, restoring them to their appropriate positions as in Fig. 10. These three stages, incorporating touch, click, and restore events, offer a comprehensive learning experience for students, helping them grasp the concepts of electrical machines more engagingly and interactively.

III. Results and Discussion

A. Students Survey Results

Most students found the metaverse-based learning environment engaging and helpful for enhancing their understanding of electrical machines. As in Fig. 11, most students evaluated that the game enhanced their understanding by answering a scale of 4 (good) or 5(very good). They appreciated the platform's interactive and immersive nature, providing a more stimulating learning experience than traditional methods.

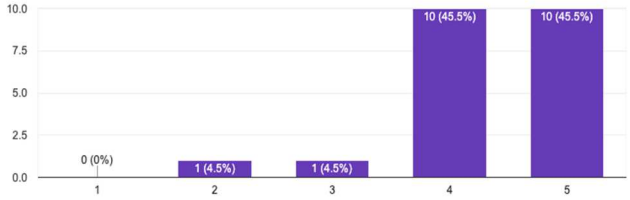

Fig. 11 Survey result on enhancing understanding using the game

Students noted that the hands-on approach of the metaverse learning environment allowed them to better understand electrical machines' concepts compared to traditional classroom settings. The visual and interactive aspects of the platform allowed students to retain more information and build a stronger foundation in the subject.

TABLE I
STUDENTS RESPONSE

Q1: What improvements would you suggest making the metaverse-based learning experience for electric machines more effective?
• I wish there were more content. • I wish the object was bigger. • I wish there was more explanation of where to go when going through the steps. • I want to touch the real DC machine. • Add a variety of activities. • It would be better if the mission message stayed in the window when given. • It would be nice if the sections were divided into easy-to-understand areas. • Refinement of the mission statement. • How to use different apps. • I hope the explanation doesn't disappear even after time passes. • If you make a little more difficult part into a game, I think my understanding will increase. And if it is a game method that induces a little more repetitive learning, it will be memorable.
Q1: Are there any activities or game mechanics you would like to add to make it more fun and engaging?
• I would like to include running. • Include fighting. • It would be nice to be able to use weapons. • The existing method was also fresh enough and fun. • I want to try metaverse-based learning with other programs, not just Roblox. • I'm not sure about how the game works. • Count and manage user's power through wrong and correct response. • It's fun this way too.

Despite the positive feedback, students also provided suggestions for improvement, such as addressing in-game bugs, improving touch recognition, expanding content and activities, providing more explicit instructions, and integrating real-life images and additional features like circuit-building. chatGPT played a crucial role in addressing the feedback received from students, as it was used to solve various bugs and implement new features. For instance, students mentioned that the dialog messages were too small to see and disappeared instantly from the screen. chatGPT provided a new code to resolve this issue, generating code to enlarge the font and place it in the appropriate location on the screen.

In response to student suggestions for game improvements, such as the inclusion of powerful weapons, fighting, and competitive running, chatGPT proved to be a valuable tool for implementing these features. By leveraging chatGPT's capabilities, the metaverse learning environment can be tailored to better align with student preferences, resulting in a more engaging and enjoyable educational experience.

B. Implementation Challenges and Successes

Addressing the implementation of this project for electrical machines presented some challenges, particularly when overcoming the limitations of college-level Roblox metaverse scripting. However, we established an engaging and interactive learning environment by tailoring the platform to the specific requirements of electrical machine education.

The successful development of the Roblox game for electrical machines was achieved by integrating pertinent content, designing specific activities, and adapting the platform to deliver an optimal learning experience for students, all facilitated by using chatGPT and open-source solutions. Compared to traditional classroom learning, metaverse-based learning provides students a more captivating and interactive experience. This immersive approach enables them to visualize and engage with electrical machines in a manner that is unattainable in conventional settings, leading to enhanced comprehension and retention of complex concepts.

Incorporating chatGPT within the metaverse learning environment was crucial in augmenting interactivity and engagement. chatGPT empowered the game for students to receive tailored support and feedback, fostering a more immersive and dynamic learning experience that better equipped them to tackle future academic and professional challenges. In addition, chatGPT's adaptability facilitated implementing new activities and features, such as weapons, fighting, and competitive running, further enriching the learning environment and addressing student suggestions. By combining the advantages of metaverse-based learning and the powerful capabilities of chatGPT, educators can create dynamic, immersive, and comprehensive learning experiences that foster better understanding and drive student engagement and motivation in the ever-evolving educational landscape.

C. Future Directions and Applications

Given the positive feedback and the successful implementation of the metaverse-based learning environment for electrical machines, there is potential for expanding its use across other disciplines and subject areas. This approach could revolutionize education by providing students with more engaging and immersive learning experiences catering to their needs and preferences. Advanced technologies such as artificial intelligence, virtual reality, and augmented reality can further enhance the metaverse learning environment. By integrating these technologies, the platform can offer more personalized and adaptive learning experiences, helping students to understand complex concepts better and develop critical skills.

Metaverse-based learning environments can also provide opportunities for collaboration and networking among students and educators from different institutions and locations. It can foster a sense of community, encourage the exchange of ideas, and facilitate collaborative problem-solving, ultimately enhancing the overall educational experience. The metaverse learning environment can also be used for professional development and lifelong learning. By offering interactive and engaging learning experiences, professionals can stay up to date with industry trends and developments, ensuring they remain competitive in their respective fields.

IV. CONCLUSION

In conclusion, the metaverse-based learning environment for electrical machines has proven to be a unique and engaging educational tool that has the potential to transform traditional educational approaches. By leveraging the immersive and interactive nature of the metaverse, students were provided with a unique learning experience that allowed them to understand better and retain complex concepts related to electrical machines.

Integrating cutting-edge technologies such as chatGPT played a pivotal role in enhancing interactivity and engagement within the learning environment. Using AI-driven language models allowed for personalized and adaptive learning experiences catering to individual student needs and preferences. It further contributed to the overall effectiveness of the metaverse-based learning environment in fostering a more profound understanding and retention of subject matter.

As the educational landscape evolves, adopting metaverse-based learning environments across various disciplines and subject areas presents a promising opportunity for revolutionizing how students learn and interact with educational content. This shift in educational methodologies can lead to more engaging, immersive, and compelling learning experiences that cater to the diverse needs of learners in the 21st century.

Furthermore, incorporating advanced technologies such as virtual reality, augmented reality, and artificial intelligence can further elevate the metaverse learning environment, offering even more personalized and adaptive learning experiences. This integration can help students to understand complex concepts better, develop critical skills, and promote a growth mindset, ultimately preparing them for success in an ever-changing global society.

The potential for collaboration and networking opportunities within metaverse-based learning environments also presents a significant advantage. It fosters a sense of community, encourages the exchange of ideas, and facilitates collaborative problem-solving among students and educators from different institutions and locations. It can enhance the educational experience, fostering global connections and promoting cultural understanding.

Lastly, the metaverse learning environment can be a valuable resource for professional development and lifelong learning, providing engaging and interactive experiences for professionals seeking to stay up to date with the latest industry trends and developments. It ensures they remain competitive in their respective fields, contributing to personal and professional growth.

In summary, the metaverse-based learning environment for electrical machines has demonstrated immense potential in transforming the educational landscape. By integrating advanced technologies, adapting the platform to the specific needs of various disciplines, and fostering collaboration and networking opportunities, metaverse-based learning environments can revolutionize education, leading to more engaging, compelling, and immersive learning experiences for students and professionals alike. The Roblox game file is downloadable from https://tinyurl.com/ykpvuz5w, and the game site is available at https://tinyurl.com/3sywyrjz.

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