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Enhancing Engagement and Understanding in Education using Augmented Reality

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Abstract

Traditional learning methods often struggle to engage students and help them comprehend complex or abstract concepts. These methods lack interactivity and real-world context and are typically static and limited, making it difficult for students to fully understand the concepts or gain comprehensive knowledge. Augmented reality (AR) technology offers a transformative solution to these limitations. By integrating the virtual objects into the real world, AR provides immersive and interactive experiences that enhance students' understanding and engagement. AR allows students to visualize complex ideas in 3D, interact with virtual objects, and explore topics in a way that feels real and easy to understand. By linking virtual elements to objects in the physical world, AR helps students understand difficult topics in a practical, real-world context. The proposed application is an AR-based website to overcome the limitations faced by traditional learning methods and offer students a better understanding.

Keywords: Augmented Reality, Immersive Learning, Real-World Context, Integrated, 3D Model.

1. Introduction

Traditional learning methods often face difficulties in enabling students to comprehend complex or abstract ideas due to poor interactivity and lack of proper visualizations [1]. However, AR helps in overcoming these limitations by integrating the virtual objects into the

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real world, thereby enhancing the user's perception and interaction with their environment [2]. Augmented reality seamlessly combines virtual objects with the real world through specialized software tools such as 3D Blender and Unity. AR has found its way into various industries, including education. The integration of AR in education has the potential to revolutionize the way each concept is taught and learned. Popular AR platforms like Apple's ARKit and Google's ARCore were introduced, enabling developers to create AR experiences for iOS and Android devices [3]. By providing students with interactive, three-dimensional models and simulations, AR enables them to visualize and manipulate abstract concepts in ways that were previously unimaginable [4]. Moreover, AR has been shown to enhance student engagement and motivation by making learning more interactive and experiential [5]. By incorporating gamification elements such as rewards and challenges, AR-based educational experiences can captivate students' attention and encourage active participation in the learning process [6]. Increased student engagement can lead to better learning outcomes and knowledge retention, as students are more likely to remember information they have actively interacted with [7]. The integration of AR into educational platforms represents a paradigm shift in how students interact with learning materials. By superimposing virtual objects into the real world, AR transforms abstract concepts into real experiences, making learning more engaging and accessible [8]. Educational platforms utilizing AR technology offer students better understanding and an interactive experience [9].

2. Related Works

This study reviews the use of AR and VR in education, especially in the teaching and learning process. It is based on library research. The analysis indicates that AR and VR offer effective solutions for both teachers and students. AR enhances the existing reality by integrating the image elements, sound effects, or text, while VR creates a new immersive environment that presents a specific topic to students in an engaging, interactive, and experiential way.[9]

In this research, the authors describe their research initiatives involving the development and implementation of an innovative augmented reality (AR) application aimed at transforming the storytelling experience. Focusing on the timeless tales of Sherlock Holmes, the resulting AR application is both visually captivating and immersive, extending beyond traditional narrative methods. This advanced program offers users an interactive journey

through the adventures of the legendary detective by seamlessly integrating real and virtual realities.[10]

A research study was conducted at a general educational institution, where an educational study using virtual and augmented reality was developed and implemented. The results of the questionnaire revealed the following: Interaction with VR in the educational process needs improvement, along with methodological recommendations and further research on how to organize this environment for various purposes, such as students researching new material, performing laboratory work, collaborating on research, and providing instructions for teachers working with students in VR. Conversely, interaction with AR in the educational process is better understood by both teachers and students, who utilize both ready-made and personalized applications.[11]

Visual coherence is a complex problem, one aspect of which involves accurate overall coloration of virtual objects in an augmented reality scene. A spectral transplantation technology is proposed that provides direct transfer of colour, brightness, and contrast characteristics from the real background to virtual objects. An algorithm for automatic selection of the optimal type of spectral transformation has been developed. [12]

This study examines the use of augmented reality in the classroom. The benefits of augmented reality (AR) over other teaching techniques, such as e-learning, courseware, and conventional methods like chalk and talk and classic books, are also emphasized in this research article. [13]

The P2(presence pedagogy) model serves as a social constructivist learning approach in a virtual world. While some learning can take place in and through a viable community of practice, our experience suggests the P2 pedagogy prompts a churn that encourages purposeful interactions, goal-oriented projects, and collaborative processes, which result in an intentional learning environment [14].

The results of this study revealed that AR cannot be implemented in general as a learning medium in schools like other e-learning media. However, the use of AR can help educators to provide knowledge for students. In the case of inclusive education, generally, the presence of AR has a positive impact and is liked by students. This shows that the existence of AR can be useful as a learning medium for inclusive education[15].

Application scenarios and functions of AR-assisted DT (Digital Twins) are summarized by following the engineering lifecycle, among which service design, production process, and Human–Machine Interaction (HMI) are hot topics. Then improvements specifically brought by AR are analyzed according to three dimensions, namely virtual twin, hybrid twin, and cognitive twin, respectively [16].

3. Proposed Methodology

The basic implementation of AR for education purposes requires several hardware tools. The proposed method utilizes a laptop equipped with WebXR. This enables the students to interact with AR models through the camera and sensors. The camera captures the real-world environment in which the AR models are overlaid and the sensors facilitate motion tracking, orientation, and interaction. Additionally, Wi Fi on the device ensures seamless interactivity within the AR environment. The Figure 1 below shows the overview of implementing AR.

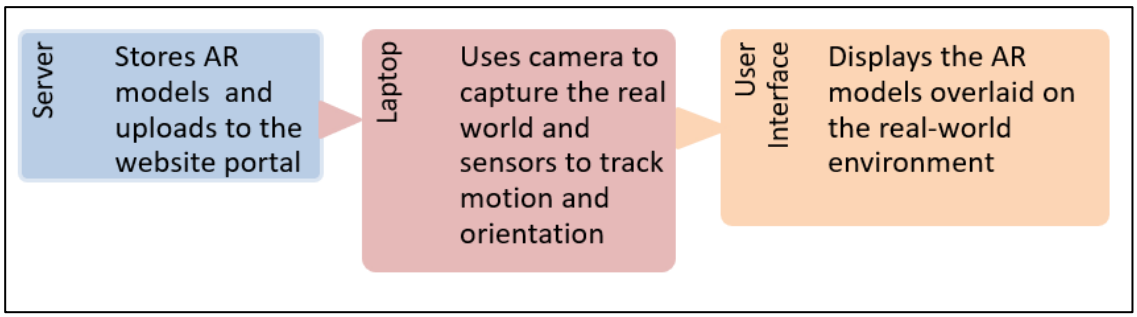

Figure 1. Overview of AR Implementation

Initially, the model's structure has been conceptualized, considering its purpose and intended environment within the augmented reality space. Utilizing Blender's robust suite of modeling tools, the intricate details were sculpted and the geometry was refined. Texture painting and UV unwrapping ensure the model's surface is visually appealing and ready for rendering. Additionally, rigging and animation were incorporated for interactive AR experiences. Throughout the creation process of AR models, attention optimization was essential for maintaining the performance within AR applications. The models are exported in a format, such as glTF or.OBJ, for integration into the AR development framework Three.js. Within the Three.js framework, loaders are utilized to import the exported model files. Once imported, the model is oriented appropriately within the Three.js environment. Lighting, shadows, and additional effects to enhance the visual fidelity of the model. The Figure 2 shows the flowchart of the proposed design.

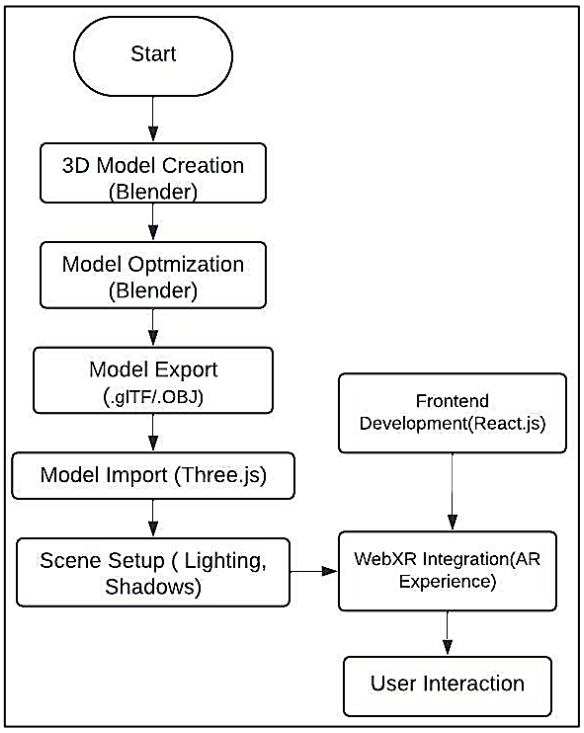

Figure 2. Flowchart of Proposed Design

Finally, user interactions and animations are integrated to create an engaging and interactive 3D experience on the website. Testing across various devices and browsers ensures compatibility and optimal performance, providing users with an immersive viewing experience of the Blender model. Through the Three.js framework,3D models are imported into the WebXR environment, enabling users to interact with virtual objects overlaid onto the real world. utilizing the WebXR's capabilities for spatial tracking, gesture recognition, and device compatibility ensures seamless integration and optimal performance across various AR-enabled devices. Without additional plugins the AR models can be rendered in the website using webXR. Finally, the front end is designed using React.js for a smooth user experience.

Figure 3 explains about the flow of the website. First the user sign up/login into the website. The user can choose the concept they need to view and after entering the AR environment the AR models are overlaid in the real time environment.

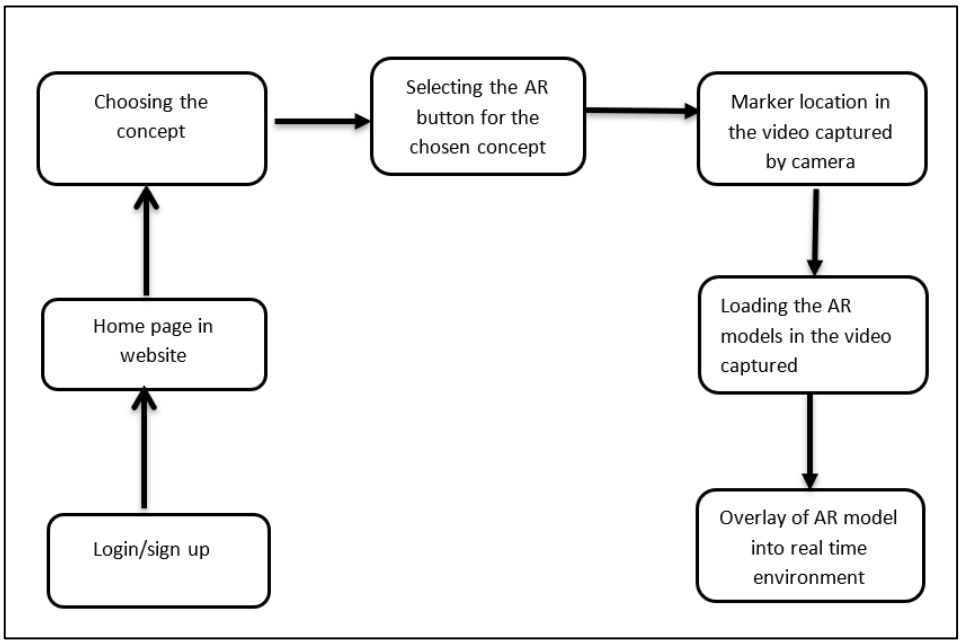

Figure 3. Flowchart of the Website

4. Results and Discussion

The use of Three.js and the WebXR enables a seamless AR experience directly within the browser, while React.js provides a smooth and intuitive user interface. Users sign up or log in to the website and select the AR concept they wish to explore. The chosen AR models are then overlaid onto the real-time environment using WebXR. Users interact with the 3D models through gestures or taps, experiencing an immersive augmented reality environment.

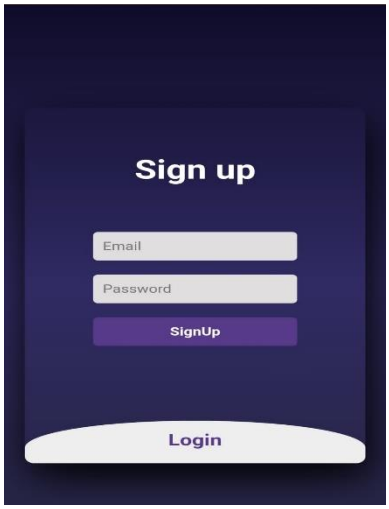

Figure 4. Sign up/Login Page

The above Figure 4 shows the sign up/login page. If the user is already an existing user, they can simply login using their credentials.

Figure 5. Home

Figure 5 shows the home page of the website, where users can select the concepts, they wish to explore and view the corresponding AR models.

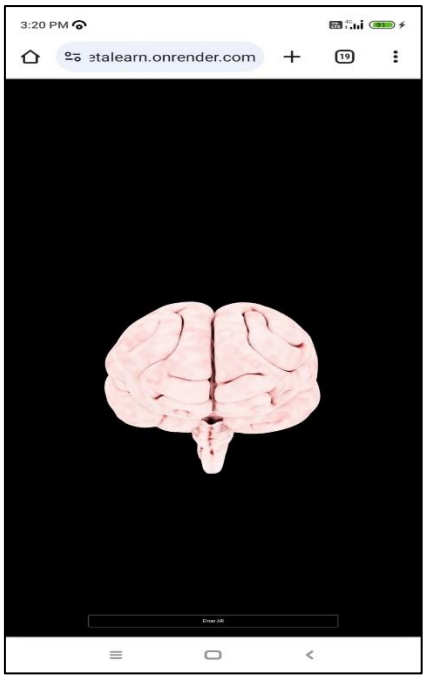

Figure 6. Model Loading in AR Environment

Figure 6 shows the AR model loaded into the environment on a laptop. Using the cursor, the user can rotate the model in any direction to obtain a 360-degree view. Figure 7 is a comparison chart showing the differences between learning websites that do not integrate AR and proposed website, which utilizes AR models. The values are based on the feedback taken

from 50 students who used both the websites. The metrics for comparison were derived from the students' general evaluations of both websites.

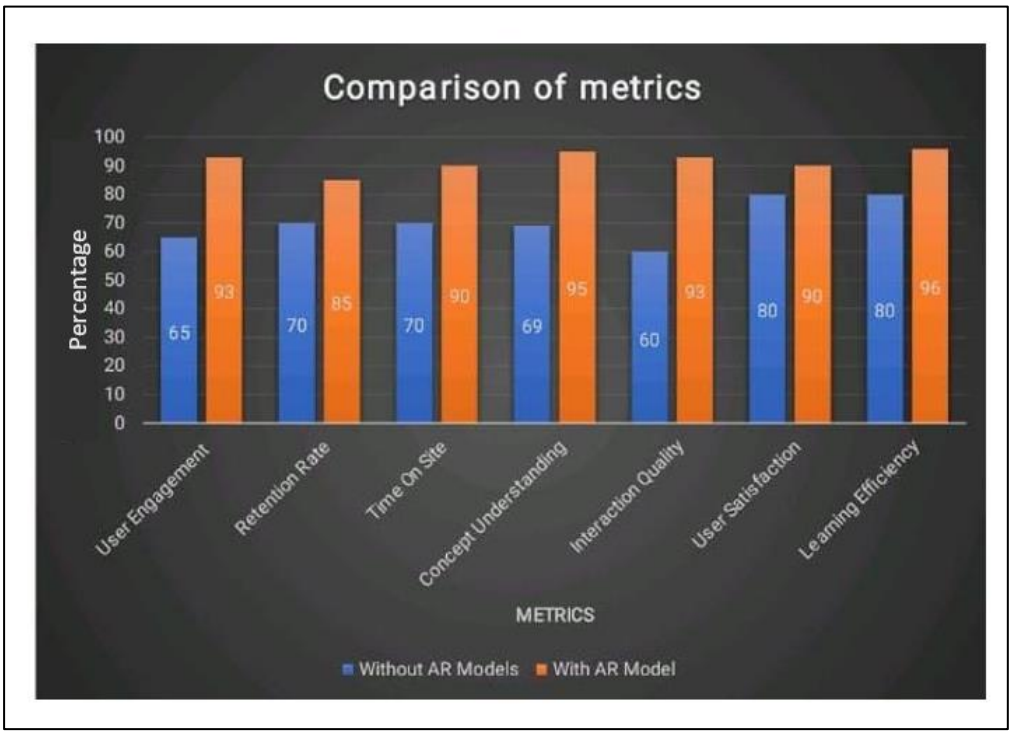

Figure 7. Comparison Chart

As the chart shows, learning efficiency on the website that integrates AR models is higher compared to websites that do not use AR. This improvement is primarily due to AR providing students with a complete 360-degree view of the models, which enhances their understanding of abstract concepts. Additionally, AR allows students to learn at their own pace, contributing to the overall effectiveness of the learning experience.

5. Conclusion

In conclusion, the integration of augmented reality (AR) technology into websites represents a significant advancement in enhancing user engagement and interaction. By integrating AR, websites can offer immersive and interactive experiences that go beyond traditional 2D content, providing users with a more compelling and memorable browsing experience. The integration of AR into websites opens a myriad of possibilities across various industries, including e-commerce, education, entertainment, and marketing. Despite the immense potential of AR technology in education, it's essential to address challenges such as accessibility, equity, and technical barriers to ensure that all students can benefit from these

innovative learning tools. The future enhancement will also include the VR (virtual reality) capabilities on the website, as this feature is still in the development stage.

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