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Enriched Learning Tool Using Augmented Reality in Computer Science Education

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***Abstract-* The use of augmented reality (AR) technology to visualize engineering terms has the potential to revolutionize the way engineering concepts are taught and understood. It examines the advantages and difficulties of utilizing augmented reality technology to improve engineering education. Existing solutions encompasses various studies highlighting the integration of advanced visualization techniques, including augmented reality (AR), into educational contexts such as architecture and engineering education. In the realm of architecture education, a study comparing traditional printed plans with interactive 3D models emphasizes the benefits of employing new systems for enhanced learning experiences. One notable drawback is the underutilization of augmented reality (AR) in computer science education thus far. While AR has shown significant promise in enhancing learning experiences across various disciplines, its application in computer science education remains limited. Often virtual environments are visualized with head-mounted- displays (HMDs) [1] that surround the user's head. This lack of integration may stem from factors such as the perceived complexity of implementing AR solutions in computer science curricula, as well as the need for specialized expertise in AR development among educators. In response to the underutilization of augmented reality (AR) in computer science education, we propose a comprehensive approach aimed at integrating AR technology into the curriculum to enhance learning outcomes. Our proposal involves leveraging platforms to develop interactive 3D models tailored to computer science concepts. These models will be seamlessly integrated into the learning environment, providing students with immersive experiences that facilitate deeper understanding and engagement with course material. To evaluate the effectiveness of our approach, we have devised metrics focusing on student engagement, comprehension, and retention. These metrics will assess factors such as interaction frequency with AR content, performance in assessments related to AR-enhanced topics, and long-term retention of learned concepts. By employing these metrics, we aim to gather quantitative data on the impact of AR technology on student learning outcomes in computer science education. The results include 3D models which are easy to visualize complex structures.**

***Keywords:* Augmented Reality, Virtual Reality, Vuforia, AR Core.**

I. INTRODUCTION

The advancement of contemporary society depends on the quality of engineering education. Unfortunately, many students find it challenging to comprehend engineering principles, particularly when it comes to oblique phrases and ideas. Augmented reality (AR) technology has recently come to light as a viable tool for improving students' understanding of engineering vocabulary and ideas. With the use of augmented reality (AR) technology, users can interact with virtual items in the present. Augmented reality (AR) represents a cutting-edge technology that overlays digital information onto the physical world, thereby enhancing real-world experiences with virtual environment [2]. Unlike virtual reality, which immerses users in entirely simulated environments, AR seamlessly integrates virtual content into the user's surroundings in real-time.

Virtual reality (VR) is an immersive technology that transports users into entirely synthetic environments, creating a sense of presence and engagement beyond the physical world. By simulating sensory experiences such as sight, sound, and touch, VR enables users to interact with and explore virtual landscapes or scenarios in real-time. Unlike augmented reality, which overlays virtual elements onto the real world, VR immerses users in a fully digital environment, often accessed through specialized headsets or immersive displays. This technology has found diverse applications, from entertainment and gaming to healthcare and training simulations, offering unparalleled opportunities for experiential learning, remote collaboration, and immersive storytelling. As VR technology continues to advance and become more accessible, its potential to transform how we perceive and interact with digital content is increasingly recognized across industries and disciplines.

Augmented reality (AR) holds immense importance in the education field as it revolutionizes traditional teaching methods by offering immersive, interactive learning experiences. By overlaying digital content onto the real world, AR captures students' attention and encourages active engagement with course material. Through AR applications, students can explore complex concepts in a hands-on manner, visualize abstract ideas more effectively, and personalize their learning experience according to their individual preferences. Additionally, AR promotes collaborative learning environments where students can work together to solve problems and explore virtual simulations. By integrating AR into education, students gain exposure to cutting-edge technologies, develop essential digital literacy skills, and prepare for future advancements in technology and innovation. Overall, AR has the potential to enhance learning outcomes, foster creativity, and empower students to succeed in an increasingly digital and interconnected world.

The primary objective of the enriched learning tool is to enhance the learning experience for students by providing them with a dynamic and visual platform that goes beyond traditional methods. Through the use of AR, learners will be able to manipulate and explore 3D models of complex mechanisms, structures, and systems, gaining a deeper understanding of their functionality and interrelationships. The interactive nature of AR allows students to zoom in, rotate, and dissect models, enabling them to grasp intricate details that are often lost in 2D representations.

With the help of the AR development platform Vuforia, programmers can create AR applications for many different operating systems, including iOS, Android, and Windows. A popular game engine for creating AR applications is Unity. A 3D modelling application called Blender is used to produce 3D models [3] for AR applications. The AR programmer we're talking about can overlay a 3D model over text within an image marker. The printed picture utilized as the image marker serves as the AR app's trigger. The software detects the image marker, which causes the 3D model to be placed above the image marker's text. The creation of the image marker is the initial stage in constructing this AR application. An image editing programme, such as Adobe Photoshop or GIMP, is used to generate the image marker. A black and white image with the backdrop and text in black should serve as the image marker.3D model over the text of the picture marker was made using Unity. The Vuforia-based image marker detection feature of the AR app is intended to overlay the 3D model above the image marker's text. Unity is a well-liked gaming engine for making AR apps.3D models for AR applications are created using the 3D modelling software Blender. The AR coder we're referring to has the ability to place a 3D model on top of text inside an image marker. The printed image used as the image marker acts as the trigger for the AR software. The 3D model is positioned over the image marker's text when the programme recognises the image marker.

II. RELATED WORKS

The author in [5] uses engineering curriculum at universities Engineering Design Graphics subjects in which, during at least one academic year, students receive basic training in systems of representation, sketching, technical drawing and CAD. However, in this context, developments of spatial abilities have not been an explicit learning objective, and their development has been considered an indirect learning outcome. Many studies lines of research have examined the nature of spatial ability and its impact on graphic education and the challenge of improving the teaching of engineering graphic subjects. Several solutions used traditional instructional methods and technologies to improve spatial ability. The technology continues to progress, options for new instructional methods arise that provide potentially effective solutions to the challenge of developing spatial skills in our students. University teaching in Europe is currently immersed in a major process of change arising from the creation of the European Higher Education Area. The new teaching model entails a methodological change in education, shifting from a teacher centred model to one that places greater importance on the work of the student. An autonomous learning environment can be frustrating for the student, which is the reason an application based on an attractive and motivational technology that facilitates the learning of the basic contents of Engineering Graphics and helps to improve student's spatial abilities. Augmented reality technology (AR), allows students to take a course in an autonomous and active way.

The author in [6] evaluate the resilience ability of first-year students of Spanish architecture degree, the comparison of two learning methodologies: the traditional generation of printed plans, and the generation of interactive 3D models using new systems of publication and interaction. The main objective of the study is to evaluate the new methodology that assumes that the use of friendly technology in the classroom makes it much easier and satisfying for students to follow the subjects, allowing better acquisition of the skills they are learning. The use of new technologies in education is an influential and rapidly evolving factor that can be found from the first cycle of primary schooling all the way through to the later stages of university education. Most of the systems that have been developed have proceeded from the initial assumptions that they allow a greater ease of learning and monitoring of content by students and a better school performance based on the academic results (typical assumption and classical error of usability studies). On the other hand, it is true to say that neither of these assumptions is based on usability and satisfaction studies previously performed in order to adjust, and change the technology and content according to the profile of the student or the specific needs of each subject.

The author in [7] imagines students focusing their mobile screens in the middle of the classroom and they will be all viewing holographic 3D objects surfacing from a table and the teacher explaining the visuals. AR is going to be a reality in the near future and this technological innovation will transform the teaching-learning process. The objective of the paper is to propose a framework for using Augmented Reality in mobile phones for engineering education. Use of mobile devices in education provide a new educational paradigm, called M-Learning, It offers many opportunities for students to work on their creativity, while at same time it becomes an element of motivation and collaboration. The paper proposes the modern way of AR technology in engineering education, a handy tool to make teaching and learning effective and also proposes an experimental setup to convert a topic to an Android App.

The author in [8] shows advancement of hardware technology, specifically in mobiles devices, has provided great computational power for running and creating sophisticated large programs such as, virtual reality, augmented reality and neural network based programs. Augmented reality (AR) is one of the finest and most exciting technologies nowadays. AR enables creating computerized objects and blending them with the real world. Which can be applied to enhance and simplify many aspects in a variety of disciplines. In result, instead of reading text and imagining experimentations it is possible to simulate the experiments through equipment and experiments as same as in real world scenarios, which can be much understandable and comprehensible. In the past decade, several institutions have adopted technological methods of teaching and learning. These instructional technologies can be used by some institutions that cannot provide enough time or proper equipment to students. This is where augmented and virtual reality are mostly favourable. In result, instead of reading text and imagining experimentations it is possible to simulate the experiments through equipment and experiments as same as in real world scenarios, which can be much understandable and comprehensible. In the paper, a model of an electric circuit is created to simulate the motion of electrons and how electric current runs through a wire and provides power for different tools. The creation of such a model involves design, modelling, simulation and animation of the model. This is done by relying on several software and frameworks such as Maya3D, Unity3D, ARKit, etc.
The author in [9] innovates educational methods such as computer--assisted instruction and learning have emerged as effective alternatives to traditional methods in the context of remote learning. These alternatives engaged students' visuospatial perspective via interaction with anatomical structures in 3D and virtual reality (VR) landscapes. VR is a technology that completely immerses the user in a digital environment, typically producing images that the user can manipulate via a controller or keyboard, albeit confined within a screen. In contrast, augmented reality (AR) technology com bines the real-world environment and digital information, allowing for the projection of images i.e. holograms onto a real backdrop. AR allows for a user to manipulate the hologram (rotating, zooming, toggling on/off), while providing perspective on the hologram as if it were an object in the real world. The user can engage with the holograms from different angles to allow for a 3D representation, while also exercising their visuospatial ability.

The challenges associated with existing solutions, including those addressed in our project, encompass several key areas. Firstly, there's the issue of limited interactivity and engagement in traditional educational methods, such as printed plans or static 3D models, which can hinder students' ability to grasp complex concepts effectively. Additionally, the reliance on outdated or cumbersome technology for content creation and delivery may pose barriers to the seamless integration of AR into the curriculum. Moreover, the lack of comprehensive training and support for educators in utilizing AR tools and platforms could impede the successful implementation of AR-enhanced learning experiences.

Furthermore, concerns about the scalability and sustainability of AR solutions, particularly in terms of infrastructure requirements and long-term maintenance, may hinder widespread adoption in educational settings. Finally, ensuring equitable access to AR technology and addressing potential disparities in digital literacy skills among students present ongoing challenges that must be addressed to maximize the potential impact of AR in education. Addressing these challenges requires a holistic approach that encompasses technical innovation, pedagogical support, and strategic planning to unlock the transformative potential of AR in enhancing learning outcomes.

III. METHODOLOGY

An AR-based application is created in Unity 3D on a topic in Computer Science course. There are several steps involved in creating the application and Fig 1 shows the way to create and deploy the application. Initially, the AR core [4] services and scene form plugin are installed in Unity. Blender tool is used to 3D models and using Unity, these models are converts as Objects. Upload these objects in local storage and sample images and videos are uploaded in augmented database. When the application is invoked, it detects the plane, on a surface containing the image, When the image is detected, the corresponding models and videos are displayed.

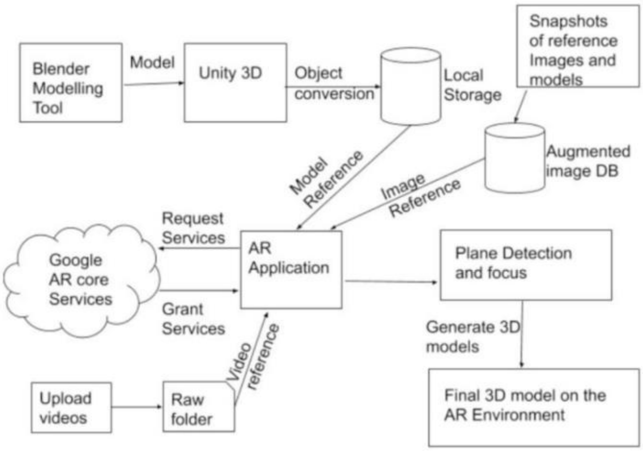


Fig. 1. Architectural Diagram

Stage 1: Modelling in Blender Environment: The complex Engineering Graphics models are modelled using Blender [10], a software tool for creation of 3D shapes. The models are modelled using the dimensions given in the book using knife tools. Models designed in blender can be coloured and reshaped as needed. The working environment of blender for creating 3D models is shown in Fig 2.

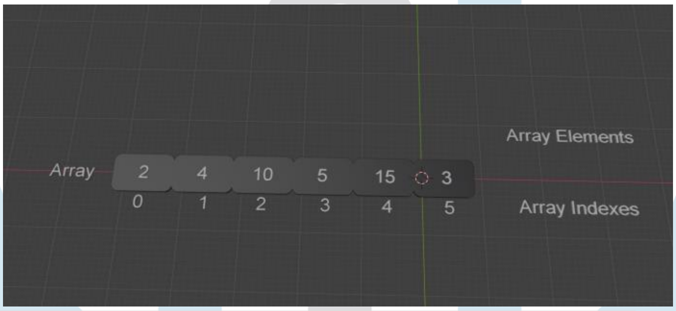


Fig. 2. 3D Model in Blender

Stage 2 Conversion from 2D to 3D Image: Unity 3D is a powerful tool for rendering FBX format objects. Scenes in scene form requires the models to be in FBX format for rendering. Unity provides services for converting models created using Blend into FBX format so that they can be imported as scene form asset in the AR environment.

Stage 3: Custom AR Fragment for Image Processing in Unity: This is the activity that extends the Google's AR Fragment for maintaining session information about the models created. It is this fragment that detects the camera focus and updates the last camera image as a frame. This frame will be used for the comparison with the images in the augmented image database. The main purpose of this fragment is to setup the session and the augmented image database.

Stage 4: Rendering Models in AR Environment (Deploy): These lines get the fragment from its ID and setup the AR environment for deploying models. The reference images are converted into bitmaps and added to the augmented image database. The above snippet creates the model as Model renderable format and builds the model from the sample reference image and adds the model to the scene as shown in Fig. 3 below. The above snippet deploys the model into the AR environment. Transformable node is used here because the models can be rotated and zoomed with the help of transformable node.

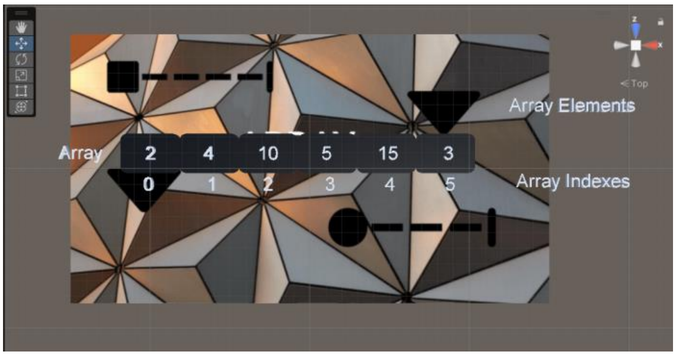
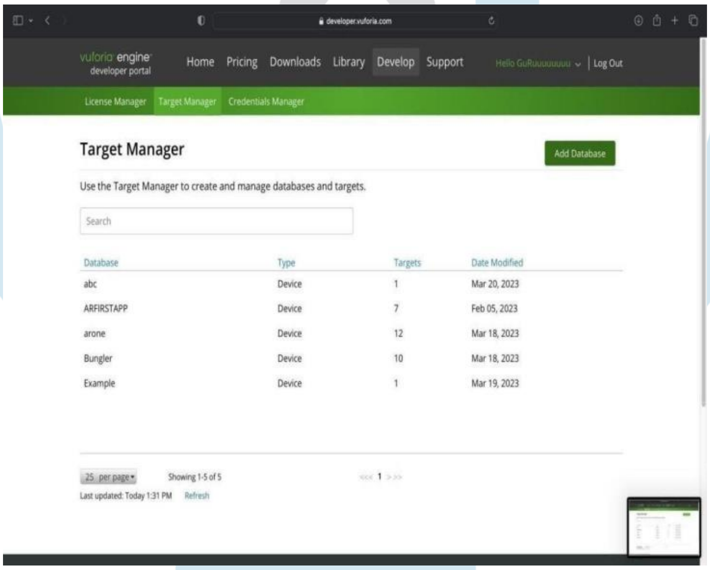


Fig. 3 Rendered 3D Model

IV. RESULTS AND DISCUSSIONS

Database: The database is implemented using Vuforia SDK [11]. Vuforia Database offers a target generation system that enables developers to create unique targets from images. This process involves converting the image into a feature-rich target that can be easily recognized and tracked by Vuforia's computer vision algorithms. Generated targets can be downloaded and integrated into AR applications. Vuforia Database utilizes advanced image recognition algorithms to identify and track specific images or objects in the real world. Developers can upload reference images to the database, which acts as a repository for storing and organizing these images. For the Enriched Learning tool, the database consisted of 10 3D Model that included Array, TCP Model, UDP Model, Stack, Five Layer Architecture, Linked List, OSI Model, Star Topology, Entity Relationship Model and Tree Model.

Table 1. Vuforia Database



Database	Type	Targets	Date Modified
abc	Device	1	Mar 20, 2023
ARFIRSTAPP	Device	7	Feb 05, 2023
arone	Device	12	Mar 18, 2023
Bungler	Device	10	Mar 18, 2023
Example	Device	1	Mar 19, 2023

The table 1 shows a database creation in Vuforia we can create a database by Going to the Target Manager in the Vuforia Engine Developer Portal and login. Click Add Database. The Create Database dialog opens. Name the database and select the Device Type option. The database name should be unique for the developer account you are using .

TCP

3D model of TCP handshake shown in Fig 4 involves several steps, including setting up the Unity project, importing 3D models of network devices, creating animations, writing scripts to handle logic and networking, setting up camera and lighting, and testing and refining the scene.

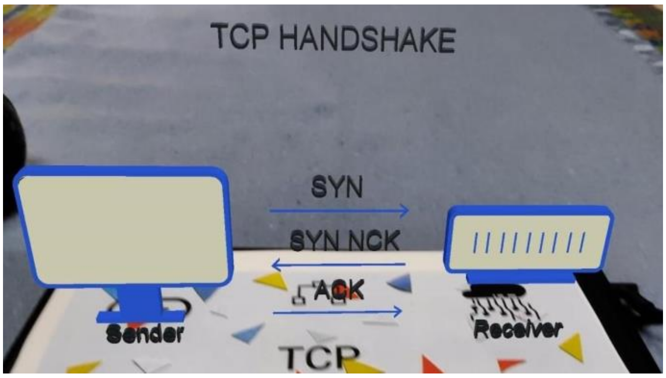


Fig. 4 TCP 3D Model

Array

The resulting array model shown in Fig 5 could be visualized and interacted with in the Unity editor or deployed to a target platform for end-users to experience. The array elements would be positioned and arranged according to the desired structure and any additional customization such as materials, textures, or animations would be applied as specified.

Fig. 5 3D Array Model

Stack

A stack as shown in Fig 6 is a fundamental data structure in computer science that follows the Last In, First Out (LIFO) principle. The two primary operations associated with a stack are push and pop. The push operation in a stack involves adding a new element onto the top of the stack. This operation increases the stack size by one and places the new element at the top position. The pop operation in a stack is used to remove the top element from the stack. This operation decreases the stack size by one and returns the removed element.

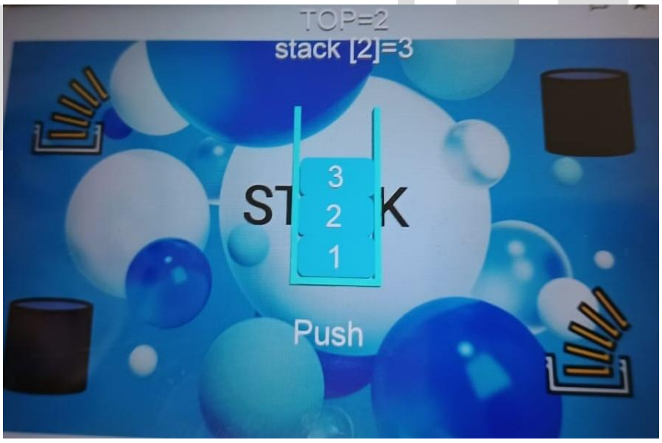


Fig. 6 3D Stack Model

Linked List

A linked list as shown in Fig 7 is a linear data structure consisting of a sequence of elements called nodes. Each node contains two parts: data and a reference to the next node in the sequence. This structure allows for dynamic memory allocation and efficient insertion and deletion of elements anywhere in the list. The linked list starts with a head node, which points to the first node of the list, and typically ends with a tail node pointing to null, indicating the end of the list.

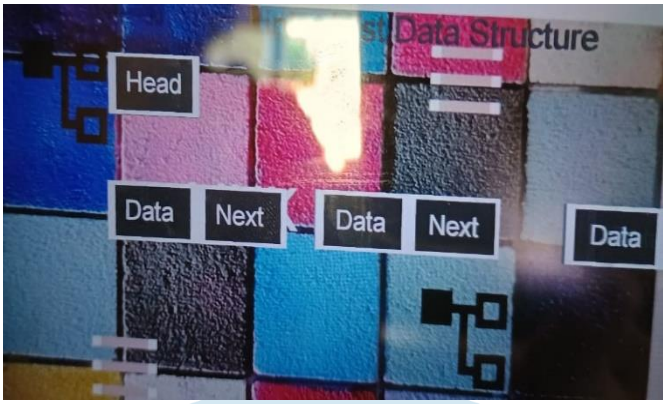


Fig. 7 Linked List 3D Model

Tree

3D Tree model shown in Fig 8 using augmented reality (AR) involves selecting an AR platform or framework, preparing the 3D model, importing it into the AR development environment, configuring tracking and scene setup, positioning and displaying the model, adding interactivity and animations (if desired), building and deploying the AR app, and testing and refining the experience. The specific implementation details may vary depending on the chosen AR platform or framework, and it requires a combination of 3D modelling skills and programming knowledge. It is important to refer to the official documentation and tutorials provided by the AR platform you are using to ensure proper implementation.AR provides exciting opportunities to enhance user experiences by overlaying virtual 3D content onto the real world, and it can be utilized in various domains such as gaming, education, design, and more.

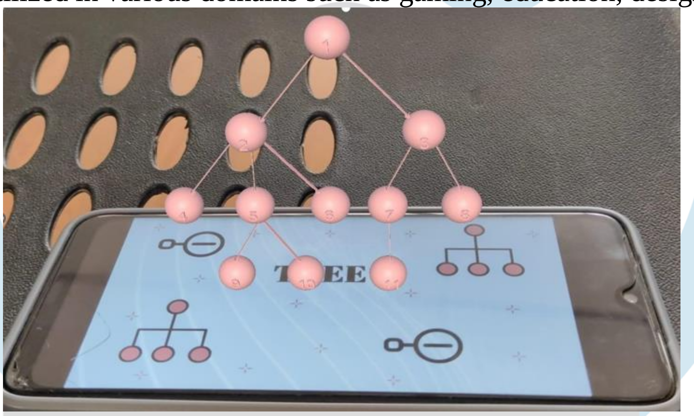


Fig. 8 3D Tree Model

V. CONCLUSION

Augmented reality (AR) is a growing educational medium for young users such as elementary and high school pupils. In the realm of architecture education, a study comparing traditional printed plans with interactive 3D models emphasizes the benefits of employing new systems for enhanced learning experiences. AR app implemented in this learning tool successfully placed a 3D model of text on an image marker using Vuforia, Unity, and Blender. For the Enriched Learning tool, the database consisted of 10 3D Model that included Array, TCP Model, UDP Model, Stack, Five Layer Architecture, Linked List, OSI Model, Star Topology, Entity Relationship Model and Tree Model. The app provided an immersive and interactive experience, and it has the potential to be used in various industries.

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