Visualize4Learning: An Augmented Reality Framework for Earth Shapes, Mechanical Parts, and Furniture Placement

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***Abstract*—In contemporary education, a significant challenge persists as many students encounter obstacles in spatial visualization, leading to difficulties in comprehending complex concepts across various disciplines. Simultaneously, there is a concerning trend in the decline of creativity among students. This decline may stem from the traditional methodologies employed in education that often fail to engage students in dynamic and immersive learning experiences. Furthermore, inadequate conceptualization and visualization of subject matters might contribute to a loss of interest among students. A lack of robust visual aids and interactive learning tools can hinder students' ability to grasp and retain information effectively. Notably, this limitation extends to the critical domain of understanding the profound impacts of climate change. The absence of proper visualization tools constrains students' comprehension of the destructive consequences of climate change, impeding the urgency for action and environmental awareness.**

The proposed solution advocates for the integration of augmented reality (AR) as a transformative solution in education. By leveraging AR technology, students can overcome spatial visualization challenges through immersive and interactive learning experiences. Moreover, AR offers a platform to revitalize creativity, fostering innovative thinking and problem-solving skills.

Keywords- Augmented Reality ,Visualisation, Education, Mechanical Parts, Home Decor,

I. Introduction

Education stands as the cornerstone of societal progress, yet it faces persistent challenges in effectively engaging and empowering students to comprehend intricate concepts. Among the myriad hurdles, the difficulty in spatial visualization poses a formidable barrier, hindering students' abilities to grasp abstract ideas across various academic disciplines. This struggle often leads to disinterest, frustration, and a lack of academic motivation among learners.

Simultaneously, there exists a concerning decline in creativity among students, attributed partly to conventional teaching methodologies that prioritize rote learning over innovative thinking. The absence of engaging, dynamic learning experiences may well contribute to this decline, limiting students' capacity to explore and apply their creative faculties.

Moreover, the inadequacy of visual aids and interactive learning tools exacerbates these challenges. Concepts that demand visual comprehension suffer when presented through conventional teaching methods lacking immersive visualization. Notably, one pressing global issue, the perils of climate change, faces a similar obstacle. The inability to vividly convey the severity of environmental degradation limits students' comprehension and urgency to address this critical issue.

Furthermore, the implementation of AR-enhanced educational tools has the potential to rejuvenate creativity by fostering innovative thinking and problem-solving skills. The introduction of experiential learning through AR not only sustains students' interest in subjects but also nurtures a deeper understanding and appreciation of the interconnectedness of the world.

II. Literature Review

The research encompassed a range of topics, each shedding light on different facets of AR integration.

The research by M. S. N. Shaharomand et.al [1]delved into the multifaceted uses of AR in education, highlighting the significance of leveraging AR's interactive and immersive features to enhance the learning process. This paper underscored how AR simulations can revolutionize teaching methodologies by overcoming limitations and affordability concerns. It emphasized the need to improve GPS signaling for more accurate simulations, ultimately enhancing the educational experience.

In a parallel study, [1] ,parents' perspectives on the appropriateness of AR technology were investigated. The research aimed to assess the impact of educational mobile apps—Animal 4D Lite and Octaland 4D—on children's learning performances. The research offered insights into how AR can augment children's engagement and comprehension in subjects like biology and natural sciences.

Another survey [2] delved into children's motivation following the use of AR for educational purposes. The study employed the ARCS model of motivational design to analyze how AR can bolster children's enthusiasm for learning. Results demonstrated that AR serves as a potent tool to cultivate children's curiosity, enabling educators and parents to foster a genuine passion for learning across subjects.

Moreover, the integration of AR into historical recreation emerged as a compelling application. [3] The paper showcased how AR technology can recreate and preserve historical sites, offering an immersive experience that bridges the past and present. The technical intricacies of designing AR applications for historical contexts were explored, underlining AR's potential to revolutionize how history is experienced and understood.

The research ventured into the realm of 3D object tracking and manipulation in AR, leveraging smartphones' computing power. Shaunak Shirish Deshmukh et.al employed AR to display 3D objects using printed images, eliminating the need for complex equipment. The technical framework involved tracking ImageTargets through cameras, allowing users to interact with 3D models and gain insights into intricate products and concepts [4].

Additionally, the exploration extended to AR's impact on children's engagement with coloring applications. Abdullah et.al investigation emphasized how AR-enhanced coloring applications can boost engagement and observation among young learners, showcasing AR's potential as an educational tool [5].

Prof. Dhananjay Gaikwad et.al introduced an approach to sharing virtual worlds, creating a social network for sharing physical places using augmented and virtual reality. The implementation leveraged TensorFlow and Google Cardboard to facilitate this novel approach, highlighting the potential for AR to connect individuals to physical environments in innovative ways [6].

Furthermore, a comprehensive comparative study of various AR software development kits (SDKs) was conducted. In [7] the study categorized these SDKs into distinct groups, emphasizing their significance in creating AR applications. Noteworthy players like Metaio, Vuforia, Wikitude, and ARToolKit were highlighted, showcasing the diverse range of tools available for AR development.

In [8] the application of AR in geometry education was explored, enabling the creation of 3D models from hand-drawn sketches. The 3D Reconstruction module detected key points from freehand sketches and generated two-dimensional planes forming a 3D object. This approach utilized Augmented Reality to transform 2D sketches into interactive 3D models, enhancing geometry education.

In the architectural domain, AR technology visualized 3D house designs in [9] .A smartphone's captured floorplan image served as a marker, initiating a complex process that utilized deep learning and integer programming. The resultant 2D coordinates were employed to render 3D house models using Unity 3D, seamlessly superimposed over the floorplan image marker using Vuforia.

Several studies have investigated the use of AR to enhance educational experiences across different levels of schooling. For instance, Liu et al. [10] explored the effectiveness of AR-based scaffolding in teaching lever principles to students with varying self-efficacy levels. They found that textual and collaborative scaffolding methods positively influenced learning outcomes, especially for students with lower self-efficacy.

Similarly, Düzyol et al. [11] examined the effects of AR applications on preschool children's understanding of spatial concepts. Their findings suggested that AR interventions facilitated improved spatial knowledge among young learners, indicating the potential of AR as an educational tool for early childhood education.

In engineering education, Arulanand et al. [12] implemented an AR framework to enrich learning experiences. Their study highlighted the benefits of incorporating AR technology in engineering curricula, offering students immersive and interactive learning environments that align with Industry 4.0 demands.

In robotics, Zhang et al. [13] introduced Dex-Net AR, a distributed deep grasp planning system utilizing AR and smartphone cameras. Their research showcased the potential of AR applications in robotics by enabling real-time grasp planning and manipulation tasks, which are crucial for robotic automation.

Furthermore, Mahmoudi et al. [14] developed a color sensing AR system aimed at enhancing interactive learning experiences for children. Their research demonstrated the feasibility of using AR technology to create engaging educational content, particularly for subjects like mathematics.

In the Mathematics Lesson using Accelerometer Sensor Interaction in Handheld Augmented Reality Application for Kindergarten by Yusof et al. [15], the authors explored the integration of accelerometer sensors into AR applications for kindergarten education. Their study highlighted the potential of interactive AR technology in enhancing mathematical learning experiences for young children.

Meta-analytical studies, such as that conducted by Cao and Yu [16], provide valuable insights into the overall impact of AR on student attitudes, motivation, and learning achievements. Their meta-analysis synthesized findings from multiple studies spanning the years 2016 to 2023, suggesting a generally positive effect of AR on educational outcomes.

In the study by Cazzolla et al. [17], the authors focused on using AR to support education in the context of Industry 4.0. Their research emphasized the importance of integrating AR tools into educational practices to prepare students for the challenges of modern industrial settings, where advanced technologies like AR are increasingly utilized.

AR also holds significant potential in the construction industry, as evidenced by Zaher et al. [18], who explored the use of mobile AR applications in construction projects. Their study demonstrated how AR can enhance project management, visualization, and communication among stakeholders, ultimately improving efficiency and reducing errors on construction sites

In the context of primary education, Zaher et al. [19] investigated the use of AR technology in schools in Perlis, Malaysia. Their findings indicated positive outcomes in terms of student engagement and knowledge retention, highlighting the value of integrating AR into traditional pedagogical practices.

To conclude, the research unveiled AR's transformative potential across various sectors, from education and historical preservation to interactive learning tools and spatial data applications, construction , robotics etc.

III. DESIGN AND IMPLEMENTATION OF THE APPLICATION

The software part comprises of an application created with Unity, divided into three separate functions, each designed to meet the unique needs of specific user groups. Fig 1 represents the system architecture diagram of the entire application . This application utilizes various AR sessions for different purposes. An AR session Origin is incorporated to oversee and monitor the 3D visual objects displayed within the environment. The backend scripts of all the motions and functions performed by the models are written in C#.

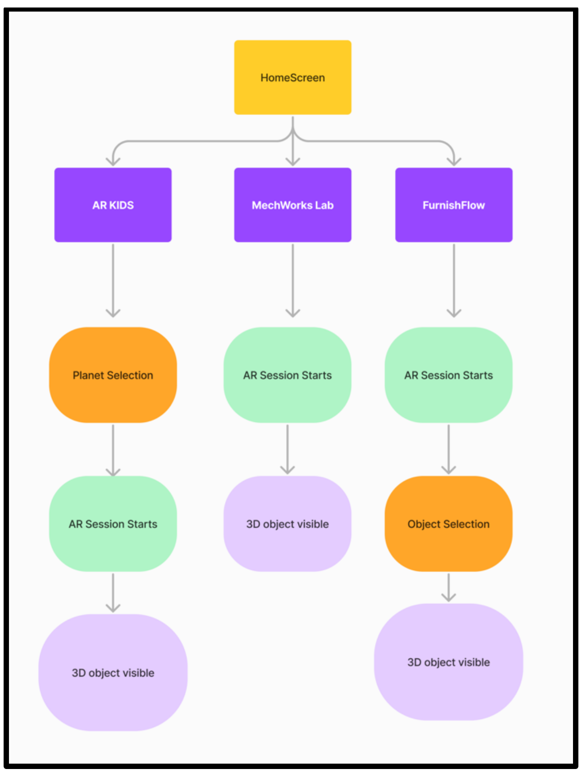

Fig. 1. System Architecture Diagram

Unity's AR Foundation is a cross-platform framework that allows you to write augmented reality experiences once, then build for either Android or iOS devices without making any additional changes. The framework is available via Unity's AR Foundation package.The Package helps detect a plane in the environment and Place out the objects onto the plane.

The application interface consists of 3 sections as that can also be visualised in Figure 2.

The 3 Sections are as follows:

1. AR Kids
2. MechWorks Lab
3. FurnishFlow

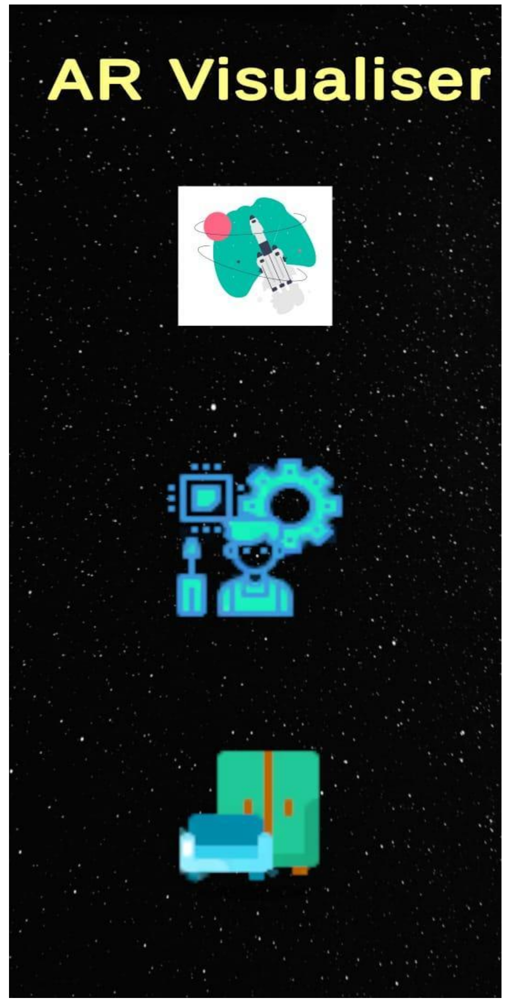

Fig. 2. Application Interface

A. AR Kids :

The Kids Section within the Unity-based application is purpose-built to engage young learners by offering an immersive and educational experience.

Tailored specifically for children, this section features an array of augmented reality models focusing on educational content suitable for their age group. At its core, this section currently showcases detailed and interactive models of the planets in our solar system , the interface of which can also be seen in Fig3. Through vibrant and engaging visuals, children can explore, interact with, and learn about the different planets, fostering curiosity and understanding about astronomy and the celestial bodies.

Fig. 3. AR Kids Section

The planetary models are constructed within Unity by utilizing its components. A sphere object serves as the foundation, onto which texture maps representing each individual planet are applied. This process imbues the spheres with the appearance of the respective planets, resulting in a comprehensive 3D planetary model. Subsequently, the specific AR model is positioned within an ARSession, allowing it to be showcased in a 3D space.

Whenever any model of a planet is clicked upon , the user can visualise an AR model of the same rotating on their phone screen in real time.

By leveraging augmented reality, this section provides an innovative learning platform that encourages exploration and knowledge retention in a fun and interactive manner, catering directly to the educational needs of young learners.

B. MechWorks Lab :

The Mechanics Section serves as a visual aid for comprehending mechanical concepts within a three-dimensional environment. Designed to cater to enthusiasts, students, or professionals interested in understanding mechanical objects, this section offers an immersive experience.

Users can explore and dissect various mechanical components, observing their intricate workings and interactions in real-time 3D, the visualisation of which can be seen in Fig 4. By enabling the visualization of mechanical systems, from simple machines to complex mechanisms, this section aids in conceptual understanding and practical learning. Its educational value extends to engineering, robotics, or physics fields, offering an interactive platform for students and enthusiasts to delve deeper into the functioning of diverse mechanical structures.

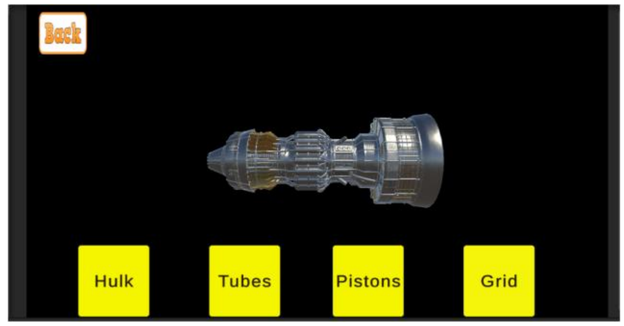

Fig. 4. Mechworks Lab.

Fig. 5. Cross section of the hulk portion

Fig. 6. Cross section of Tube portion

As we can see in Figure 4, Each button displayed on the screen corresponds to a specific subcomponent of the mechanical object, such as the turbine, which comprises distinct parts like the Hulk, Blades, Pistons, Grid, and more which can be seen in Figure 5 and Figure 6.. When a particular button is tapped, it triggers the visibility toggling of the associated subcomponent. So a particular cross section with those components will be visible. This action hides or reveals the chosen sub part, allowing users to interactively show or hide individual elements of the turbine as per their selection.

C. Furnish Flow :

The Home Decor Tool section provides a practical and innovative application of augmented reality technology for home planning and interior design purposes. Aimed at homeowners, interior designers, and architects, this tool empowers users to virtually arrange and visualize household objects, furniture, and decor elements within a three-dimensional space.

As visible in Figure 7. , By overlaying digital representations of various home items onto real-world environments, users can experiment with different arrangements, placements, and designs, facilitating informed decision-making for interior design projects. This section stands as a valuable utility, allowing users to preview and assess how different elements might look and fit within their living spaces, enhancing the home planning and decor visualization process significantly.

Each image displayed on the screen represents a specific 3D model. When a user tracks an open area and clicks on an image, that particular image is selected. Subsequently, wherever the user taps on the screen, the selected 3D object corresponding to the chosen image is placed at that location in the 3D environment. This interaction allows users to select an image and position its associated 3D model freely within the space by tapping on the screen and basically check how that particular furniture model will look in their homespace.

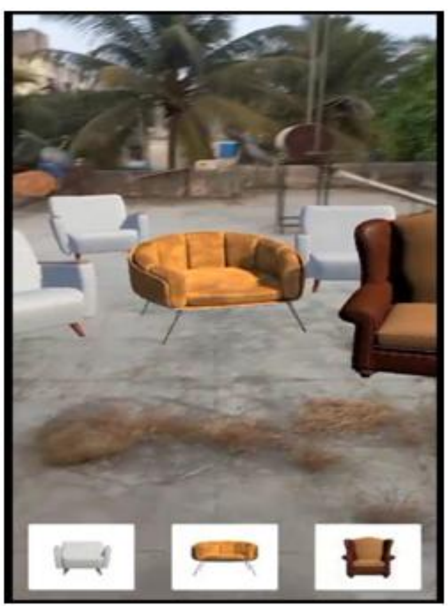

Fig. 7. Furnish Flow

IV. RESULTS AND CONCLUSION

The Unity-based application stands as a testament to the versatility and practicality of augmented reality technology across various domains. The three distinct sections - Kids, Mechanics, and Home Decor Tool - demonstrate the adaptability of augmented reality in catering to diverse user interests and needs. The Kids Section provides an engaging educational platform, allowing young learners to explore and comprehend astronomical concepts through interactive AR models of celestial bodies. This section promotes curiosity and learning in an immersive environment, enhancing educational experiences for children. Similarly, the Mechanics Section offers a unique perspective for enthusiasts and learners by visualizing mechanical components in a three-dimensional space. It serves as an invaluable educational tool, aiding in the understanding of mechanical systems and concepts across engineering and related fields. Moreover, the Home Decor Tool showcases the practical application of augmented reality in interior design and home planning. By virtually arranging household items in a 3D environment, users, including homeowners, designers, and architects, can experiment with various designs and placements, facilitating informed decision-making for interior spaces.Throughout these sections, the integration of augmented reality seamlessly within the Unity environment empowers users to interact with digital content in real-world settings, fostering engagement and learning in innovative ways.

This application underscores the potential of augmented reality technology to revolutionize education, visualization, and practical applications across diverse industries. Moving forward, continued advancements in AR technology promise further enhancements, offering boundless opportunities for immersive and interactive experiences in various domains.

V. FUTURE SCOPE

The future scope for the Unity-based augmented reality application is broad and promising. It includes expanding educational content beyond the solar system in the Kids Section, incorporating more mechanical systems in the Mechanics Section, and enhancing the Home Decor Tool with features like real-time scaling and style recommendations. Further developments could enable multi-user collaboration, integration with emerging tech, optimization for mobile platforms, and specialized modules for various industries. Additionally, empowering users to create and share content could foster a community-driven platform. By embracing innovation and refining features, the application aims to stay at the forefront of immersive experiences across diverse domains.

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