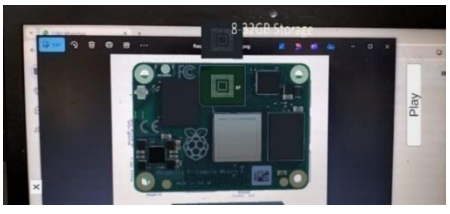
# CHAPTER 7

# IMPLEMENTATION AND EVALUATION

## 7.1 INTRODUCTION

An Augmented Reality based didactic system was developed To implement AR functionality, Unity3D SDK with Vuforia was utilized to enable key capabilities within the application. These include detecting planes, surfaces, and objects in the real-world environment, which serve as anchors for overlaying 3D models and digital content. The AR system should support user interactions such as tapping, rotating, or scaling objects, ensuring a responsive and immersive experience. Additionally, accurate tracking of motion, position, and orientation is essential for aligning virtual elements with real-world movements, which is achieved through the integration of spatial anchors. For more advanced features, developers can incorporate artificial intelligence or machine learning algorithms to enable functionalities like object recognition or gesture-based controls. Cloud anchors can be used to support shared AR experiences among multiple users in the same environment. Furthermore, linking the app to back-end services or databases allows for dynamic content updates, personalization, and data-driven experiences. ***Figure 7.1 and 7.2*** depicts the prototype of Raspberry pi and Aircraft engine during the usage of the students in remote learning.

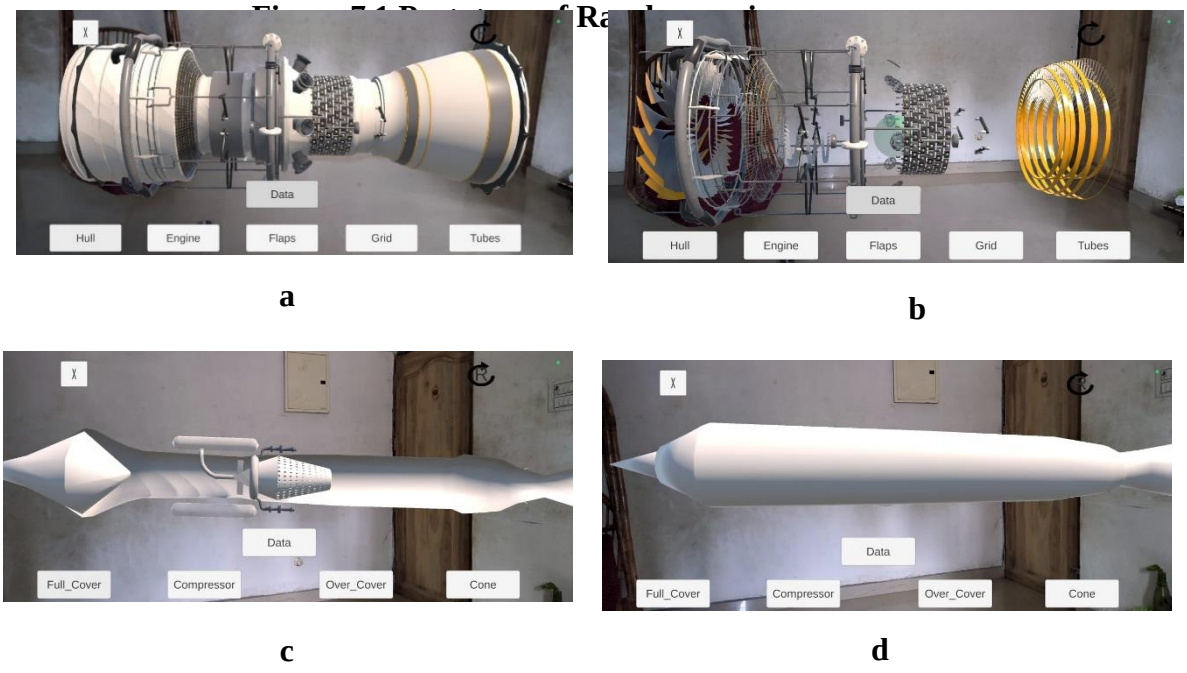
**a**




**b**



c d e




a b

c d

**Figure 7.2 Prototype of Aircraft Engine (Midair Position)**

Validation plays a great role in evaluating the effectiveness of the didactic system. It involves a systematic process to ensure that it meets functional, performance and usability requirements before deployment.For the evaluation of AR-based learning didactic system, a comprehensive assessment approach involves quantitative, qualitative, and comparative analyses. Quantitative analysis focuses on measurable data such as User Engagement, Learning Effectiveness, Device Compatibility and performance to determine the effectiveness of the application. Qualitative analysis complements this by exploring user experiences, perceptions, Content Quality, Immersion & Interactivity and User Satisfaction. Meanwhile, comparative analysis involves benchmarking the AR application against other learning tools or traditional methods to highlight its relative strengths and weaknesses.

## 7.2 QUANTITATIVE ANALYSIS

The comparison of several AR (Augmented Reality) educational applications based on four key parameters: user engagement, learning effectiveness, device compatibility, and performance (specifically low latency). Among the listed apps, the

Proposed AR System demonstrates the highest overall scores, achieving 96.6% in user engagement, 93% in learning effectiveness, 95% in device compatibility, and 92% in performance, indicating a highly optimized and learner-friendly platform. The comparison of quantitative analysis between AR based didactic system with exixting system is depicyed in ***Table 7.1***

**Table 7.1 Quantitative Analysis of AR-based didactic learning System**

| AR App Name | User Engagement | Learning Effectiveness | Device Compatibility | Performance |
|---|---|---|---|---|
| **Merge EDU** | 92% | 88% | 90% | 85% |
| **AR Flashcards** | 75% | 70% | 95% | 90% |
| **Assemblr EDU** | 85% | 80% | 88% | 82% |
| **Quiver** | 78% | 72% | 85% | 80% |
| **JigSpace** | 84% | 85% | 92% | 88% |
| **Google Expeditions** | 90% | 87% | 80% | 78% |
| **Proposed Didactic AR System** | 96.6 | 93 | 95 | 92 |

Merge EDU and Google Expeditions also show strong engagement and effectiveness but fall slightly behind in performance or compatibility. JigSpace offers a balanced performance across all parameters. In contrast, AR Flashcards ranks lower in learning effectiveness despite its high device compatibility and low latency. Overall, the table highlights that while existing AR tools vary in their strengths, the proposed system outperforms them in delivering an effective and responsive AR learning experience.

## 7.3 QUALITATIVE ANALYSIS

The comparison of several AR educational applications based on four key criteria: usability, content quality, immersion and interactivity, and user satisfaction. Among the listed apps, the Proposed AR System outperforms all others, scoring the highest across all categories—95% usability, 96% content quality, 93% immersion and interactivity, and 94% user satisfaction—indicating a well-rounded and effective solution. ***Table 7.2*** depicts the Qualitative Analysis of the AR based didactic system in comparison with existing systems.

**Table 7.2 Qualitative Analysis of AR-based didactic learning System**

| AR App Name | Usability | Content Quality | Immersion & Interactivity | User Satisfaction |
|---|---|---|---|---|
| **Merge EDU** | 90% | 88% | 92% | 89% |
| **AR Flashcards** | 85% | 70% | 65% | 75% |
| **Assemblr EDU** | 80% | 85% | 80% | 82% |
| **Quiver** | 88% | 78% | 75% | 80% |
| **JigSpace** | 92% | 90% | 88% | 87% |
| **Proposed Didactic AR System** | 95 | 96 | 93 | 94 |

JigSpace and Merge EDU also perform strongly, particularly in usability and immersion. Assemblr EDU maintains a balanced profile, while Quiver show moderate performance. AR Flashcards, although easy to use (85%), scores relatively low in immersion (65%) and content quality (70%), which may impact overall learning engagement. This comparison highlights the strengths of the proposed AR system in delivering a high-quality, interactive, and satisfying educational experience.

## 7.3 COMPARITIVE ANALYSIS

***The Table 7.3*** outlines key evaluation criteria for benchmarking Augmented Reality (AR) applications used in education, categorized into quantitative, qualitative, and mixed types.

**Table 7.3 Comparative Analysis of AR-based didactic learning System**

| Metric | Best Performing App | Lowest Performing App | Comment |
|---|---|---|---|
| **User Satisfaction** | Proposed didactic AR system (94%) | AR Flashcards (78%) | Proposed AR system offers deeper engagement through tactile and visual feedback. |
| **Learning Outcome Improvement** | Proposed didactic AR system (96%) | AR Flashcards (74%) | Proposed AR system shows better outcomes in specialized domains. |
| **Ease of Use** | Proposed didactic AR system (95%) | Human Anatomy Atlas (80%) | Simpler interfaces cater better to younger students. |
| **Interactivity** | Proposed didactic AR system (93%) | AR Flashcards (72%) | Proposed AR system offers object-based interactivity that is more engaging. |
| **Engagement** | Proposed didactic AR system (96.6%) | AR Flashcards (75%) | 3D manipulation increases student retention. |

The proposed didactic AR system consistently outperforms others in most categories, with the highest ratings in user satisfaction (94%), ease of use (95%), interactivity (93%), and engagement (96.6%). This indicates its strong overall design, user-centric interface, and immersive learning capabilities. In contrast, AR Flashcards rank lowest across most metrics, particularly in interactivity (72%) and learning outcomes (74%), suggesting limitations in their depth and engagement potential. Merge Cube, while not always at the top, is recognized for its tactile and visual interactivity, enhancing user engagement. Overall, the data underscores the importance of interactive, user-friendly design in AR educational tools for maximizing learning and engagement.

## 7.4 SUMMARY

The AR based didactic learning system was developed with the help of deep learning techniques, 6DoF and CLACHE. The evaluation reveals that the Proposed AR Learning Application consistently outperforms other existing apps across all analyzed dimensions. Its high engagement, content quality, interactivity, and user satisfaction suggest it is a strong candidate for educational deployment. On the other hand, apps like AR Flashcards exhibit significant shortcomings in both qualitative and quantitative areas, indicating the need for more immersive and interactive design. Comparative analysis reinforces the importance of UI simplicity, content specialization, and tactile engagement in delivering effective AR-based learning experiences.