International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

# An Immersive and Adaptive Virtual Reality-Based Solar System Learning System Using Generative AI

**Dheeraj Vaswani, Anushka Mane, Nikhil More, Sanjana Nitnware,**
**Priyanka Patil, Anuradha Sangram Solanki**
KIT's College of Engineering (Autonomous), Kolhapur, India

**Abstract- — Our research presents the design and im-plementation of an immersive Virtual Reality based educational system for learning about the Solar Sys-tem, enhanced with Generative Artificial Intelligence. Traditionally the spatial and dynamic relationships between celestial bodies aren't conveyed effectively. Hence, to reduce this limitation, the system uses Unity D to create an interactive virtual reality environment where everyone can explore all celestial bodies in real time. The system also uses a Gemini Generative AI API to provide dynamic, context-aware explanations with respect to the level of knowledge of the learner. The combination of immersive visualization and adap-tive learning keeps students engaged, while making complex concepts feel natural and intuitive, rather than overwhelming. The system is also built on a scalable architecture, meaning future capabilities like performance tracking and intelligent assessments can be added without rebuilding from the ground up.**

**Keywords- Virtual Reality, Generative AI, Solar System, Unity 3D, Adaptive Learning, Immersive Ed-ucation, 3D Visualization, Interactive Learning, Artifi-cial Intelligence in Education.**

## I. INTRODUCTION

Recently educational technologies have created numer-ous opportunities for personalized learning along with interactive options. Vitual Reality (VR) is the latest trend-ing and a powerful tool for creating environments where learners explore complex subjects in engaging manner.

In our project work we are representing a Solar System Learning environment developed using VR technology. In earlier decades only 2-Dimensional educational platforms existed, but now learners can experience a fully interactive 3D space, here they can view planetary structures, their relative sizes and orbital movements in real time. We have used Unity 3D for building the environment, enabling realistic rendering. and seamless VR integration.

Next we have also used Generative AI integration using Gemini AI API, its use is that whenever a user interacts with celestial bodies, the system generates context-aware

explanations rather than relying on pre-defined content. This helps learners understand everything as per their understanding. Hence making learning personalized and adaptive.

This pairing of immersive visualization with AI-driven interaction naturally pushes students toward active explo-ration. This overcomes the limitations of 2D where only simple watching or reading was possible. This shift from passive to interactive learning helps students build a much stronger interest of astronomical concepts and sparks a genuine curiosity about space science.

## II. LITERATURE REVIEW

As known, Virtual Reality is one of the promising tools in modern education, students now have better under-standing of concepts, that are too complex to grasp using traditional teaching alone.

Radianti et al. worked on immersive VR as it is being used in higher education, examining the design choices, learning theories, and subject areas where it tends to show up most. They understood that Virtual Reality helps students stay engaged and develop spatial understanding, mainly because it creates a strong sense of actually being somewhere. They also pointed out a recurring problem which was that most systems are built with usability in mind rather than measurable learning outcomes, which meant that there's still work to be done in order to evaluate whether any of this is actually working [1].

Freina and Ott also contributed to this research where immersive VR does a particularly good job of motivating students and keeping them engaged. They observed the interaction and genuine involvement as the tending things to make VR-based learning work well. They also made the practical point that VR is suited for simulating en-vironments and helping students where they could never physically reach, like the outer space [2].

Minocha et al. had focused on how VR plays out in ge-ography and science education, specifically through virtual field trips. Their work showed how enquiry based learning works, where learners have close encounter with real en-vironments, and that VR works well both as preparation before a physical trip and as a follow-up tool afterward [3]. Moro et al. changed the perspective towards medical and anatomical education, comparing Virtual Reality with Augmented Reality.They recieved the results that sug-gested in terms of raw knowledge acquisition, VR and AR perform about as well as traditional approaches, but with the added benefit of higher engagement. For some users with motion sickness this continued to be a limitation. [4]. Leung et al. worked on interdisciplinary education and found Virtual Reality to be a strong fit for collaborative, hands-on learning. Their work sited learning theories and argued that VR gives students a way to interact with ideas that would have stayed unknown [5].

Nadim et al. worked on VR-based learning environment built specifically for training applications, here the simu-lations allowed learners to gain real life experiences where making mistakes carries no real world risks. Their work combined architectural model with content management and data frameworks [6].

Birt and Hovorka combined VR with other visualization methods like printing and projections. They concluded that mixing these various approaches produce better un-derstanding and learner engagement [7].

Overall, the existing research makes a fairly clear case that VR is effective for immersive, experience-driven learn-ing across a wide range of subjects. However, a key limi-tation that emerges is the lack of integration between im-mersive VR environments and adaptive, intelligent content generation systems. That gap is precisely where this work positions itself, bringing these two capabilities together to create learning experiences that are not just immersive, but also dynamic, personalized, and responsive to the learner.

## III. TECHNOLOGY STACK

We built the system using technologies that help create immersive interaction, and adaptive content generation within a virtual environment.

**Unity 3D Engine:** Created the VR environment, that supports real-time rendering and physics simulation.

**XR Interaction Toolkit:** This provides function-ality for user interaction, and controller-based navigation within the VR space.

**Gemini Generative AI API:** It creates explaina-tions based on adaptive and personalized content delivery.

**C# Scripting:** Implements core system logic, in-cluding interaction handling, and communication with the AI API.

**World-Space UI and Text-to-Speech:** It presents generated content within the virtual environment through visual interfaces and audio narration, enhancing accessi-bility.

**JSON-Based Storage:** It stores user interaction data and system responses, enabling future analysis, per-sonalization, and scalability.

These technologies are integrated to create a system where user interaction in the virtual environment triggers context-aware content generation, which is then presented easily through visual outputs.

## IV. SYSTEM ARCHITECTURE

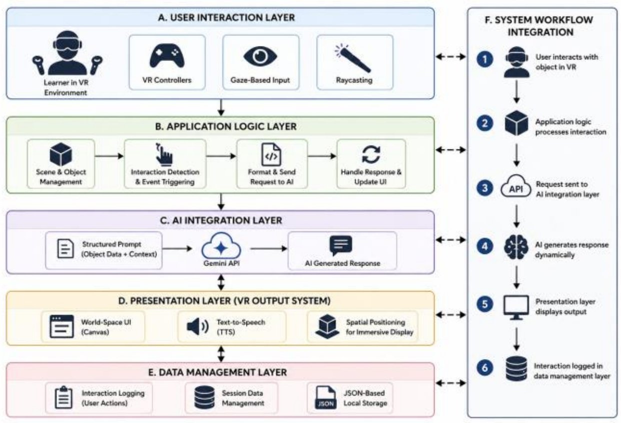


Fig. 1. Layered System Architecture of the VR-Based Learning System

Fig. 1 shows the layered system architecture, the user interaction, application logic, AI integration, presentation, and data management layers.

We built system that follows modular architecture that combines Virtual Reality, Generative AI, and data man-agement components to create an immersive and adaptive learning experience. This architecture is divided into five

International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

primary layers: 1. User Interaction Layer, 2. Application Logic Layer, 3. AI Integration Layer, 4. Presentation Layer,5. and Data Management Layer.

**1. User Interaction Layer**

This layer is built using Unity XR framework and the XR Interaction Toolkit. Its functionality is to represent the interface between the learner and system within vir-tual environment. Learner interacts using VR controllers, gaze-based input, or raycasting mechanisms. This layer is responsible for:

- Capturing user inputs such as object selection and navigation
- Enabling interaction techniques like teleportation and pointing
- Providing real-time feedback through visual cues and object highlighting

**2. Application Logic Layer**

This application logic layer serves as the core processing unit of the system and is built using C scripts within Unity. It manages scene behavior, interaction handling, and communication between the different components of the system. It is responsible for:

- Managing the virtual environment and object be-haviors
- Detecting user interactions and triggering appro-priate events
- Formatting and sending requests to the AI module
- Handling responses and updating the user interface accordingly

**3. AI Integration Layer**

This layer connects the system to the Gemini AI API, which handles the generation of dynamic and context-aware explanations for the learner. When a user selects a celestial object following things happen:

- The object data is packaged into a structured prompt and sent to the API
- The AI processes the request and generates a suitable explanation
- The response is delivered back in real time to the application layer

This layer supports adaptive learning, also there is no need to depend on static datasets.

**4. Presentation Layer**

This layer is also called as the VR output system. It is responsible for delivering the generated content within the virtual environment that feels natural and immersive. It comprises of:

- World-Space UI (Canvas) for displaying textual explanations directly within the 3D environment
- Text-to-Speech (TTS) for audio narration of the generated content
- Spatial positioning of UI elements to maintain immersion and readability throughout

This layer ensures that information flows seamlessly into the virtual environment without pulling the learner out of it.Attention is ensured.

**5. Data Management Layer**

The data management layer stores and tracks user interactions, using a lightweight JSON-based system. This layer is responsible for:

- Logging user actions such as selected objects and requested explanation types
- Maintaining session data for future analysis
- Supporting scalability for features like performance tracking and personalization

**6. System Workflow Integration**

All layers work together in a coordinated pipeline as follows:

- The user interacts with an object in the virtual environment
- Then application layer processes the interaction

- A request is forwarded to the AI integration layer
- The AI generates a response dynamically
- The presentation layer displays the output to the learner
- The interaction is logged in the data management layer

This architecture ensures scalability, maintainability, and efficient integration of immersive and adaptive technolo-gies.

## V. METHODOLOGY


Fig. 2. Workflow of the VR-Based Adaptive Learning System

Fig. 2 represents the system workflow, explaining the sequence from user interaction in the virtual environment to AI-based context-aware content generation and output presentation. It highlights the flow of data between inter-action, processing, AI response generation, and delivery. The methodology steps are as follows:

**1. Beginning of the virtual Environment**
The system starts with VR headset that is compatible. Then application loads a virtual scene using the Unity XR framework and it then tells how device is tracked, controls input and spatial mapping. Learner's perspective is considered within the virtual space, enabling natural movement and interaction.

**2. Rendering of the Solar System Environment**
The next step includes a fully 3D Solar System envi-ronment rendered using Unity's scene management and rendering pipeline. Celestial objects are modeled using primitives and procedural techniques to maintain original-ity. Spatial arrangement, scaling, and orbital animations are implemented to reflect relative positioning and motion. This enhances the understanding.

**3. User Interaction with Celestial Objects**
Here, in this step the interaction is handled through the XR Interaction Toolkit, users select objects using ray-casting, controller input, or gaze-based mechanisms. Each celestial object carries its own colliders and interaction scripts that pick up on user input and shows the relevant events in response.

**4. Data Transmission to Generative AI**
Once an object is selected, the relevant details — such as the object's name, type, and any additional context like the user's preferred explanation depth — are pulled together into a structured request. This request is then sent to Gemini Generative AI API through HTTP com-munication.

**5. Dynamic Content Generation**
Next, the Gemini API considers the request and gener-ates a context-aware response. The response shifts based on the learner's input parameters, allowing the complex-ity, level of detail, and focus to vary accordingly. This explicitly removes the need for fixed, pre-written content entirely.

**6. Presentation of AI-Generated Output**
Now, the generated response appears inside the virtual environment has the information that feels like a natural scene and not just some animated stuff. Text to Speech optional layer is used for making it more engaging for students.

**7. Adaptive Learning using User-Controlled Refinement**
Learners can go beyond a single explanation, they can choose further clarification by choosing options like sim-plify or explain in detail. Each of these choices sends a fresh request to the API, allowing the system to adjust and expand the explanation based on where the learner currently needs more understanding.

**8. Interaction Logging and Data Storage**
When any user interacts with objects they selected, what kind of explanation they asked for, and when, all the date is stored locally in a JSON-based format. This helps create a record that can later support features like performance tracking, learning analytics, and personalized content recommendations.

So, this methodology clearly helps create immersive visualization and adaptive content generation that not only supports learning process but also makes it paced, genuinely personal and interactive.

## VI. SYSTEM IMPLEMENTATION AND RESULTS

The implementation demonstrates the following out-comes:

**1. A Fully Functional Immersive VR Solar System Explo-ration Platform**
Our work shows how effectively learners can navigate within 3D representation, i.e the virtual Solar System. Learners learn about celestial bodies using spatial rela-tionships, interaction with objects in real time using VR controllers. This helps for imagination to go beyond 2D representation.

**2. Dynamic, AI-Generated Explanations**
Next, we also generate the context aware explanations using the Gemini API based on user interaction. Unlike static content,the responses are adaptable, providing rele-vant information in real time. This shows successful inte-gration of Generative AI within the virtual environment.

**3. Adaptive Explanation Control**
OWe built the platform that supports user-controlled modification of explanations, which means learners can request detailed descriptions. This enables flexible in-teraction with the content and explains the capability to provide multiple levels of explanation based on user preference.

**4. Integrated Text-to-Speech Output in VR**
All the generated explanations are shown within the virtual environment using world-space UI. This ensures that

information is delivered both visually and audibly without breaking immersion, enhancing accessibility.

**5. Scalable and Modular System Design**

As explained we have a modular architecture followed, hence the design separates interaction handling, AI inte-gration, presentation, and data management components. This helps us to engage in future enhancements such as addition of quizzes, analytics, and performance tracking.

**6. Limitations and Future Evaluation**

Although the system has successful implementation of immersive VR based Solar system interaction, yet the evaluation for its educational effectiveness is not yet been considered. Hence, in future the focus will be on under-standing the user studies, performing outcome analysis and usability testing to access its impact on learner en-gagement and knowledge retention.

## VII. CONCLUSION

Our research work represents an immersive Virtual Reality-based Solar System learning system brought to-gether with Generative Artificial Intelligence. The system combines real-time VR interaction with AI-driven content generation using Gemini API to deliver learning experi-ences that are dynamic and adaptive. This technology has made spatial concepts easier to visualize and understand, while the Generative AI component helps in by providing explanations that are context-aware and specific to the individual learner.

The system as implemented shows that pairing immer-sive environments with intelligent content generation is not just theoretically appealing but practically achievable. In doing so, it works around the limitations that have long held back both traditional teaching methods and existing digital learning tools, and contributes something meaningful to the broader effort of building more advanced educational systems.

Looking ahead, the next phase of this work will involve putting the system in front of real users to properly measure its educational effectiveness. Beyond that, the plan is to extend its capabilities further by bringing in in-telligent assessments, performance tracking, and coverage of a wider range of subjects.

## REFERENCES


1. J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, “A systematic review of immersive virtual reality applications for higher education,” Computers & Education, vol. 147, 2020.
2. L. Freina and M. Ott, “A literature review on immersive virtual reality in education: State of the art and perspectives,” 2015.
3. S. Minocha, S. Tilling, and A.-D. Tudor, “Role of Virtual Reality in Geography and Science Fieldwork Education,” 2018.
4. C. Moro, Z. Štromberga, A. Raikos, and A. Stirling, “The effectiveness of virtual and augmented reality in health sciences and medical anatomy,” Anatomical Sciences Education, vol. 10, no. 6, pp. 549–559, 2017.
5. T. Leung, F. Zulkernine, and H. Isah, “The Use of Virtual Re-ality in Enhancing Interdisciplinary Research and Education,” 2018.
6. W. Nadim, M. Alshawi, J. Goulding, P. Petridis, and M. Sharp, “Virtual Reality Interactive Learning Environment,” 2018.
7. J. Birt and D. Hovorka, “Effect of mixed media visualization on learner perceptions and outcomes,” Proceedings of the 25th Australasian Conference on Information Systems (ACIS), 2014.
8. M. D. H. Rahiem, “Generative AI in higher education in In-donesia: Patterns of use and learning impact,” Social Sciences & Humanities Open, vol. 13, 2026.
9. Unity Technologies, “Unity 3D Documentation.” [Online]. Avail-able: https://docs.unity3d.com/. Accessed: Mar. 2026.
10. Google, “Gemini API Documentation.” [Online]. Available: https://ai.google.dev/