Prehistorical VR simulation as an educational content

R25-056

Project Proposal Report

Waynath S.P.K | IT21803420

B.Sc. (Hons) Degree Information Technology Specializing in Interactive Media

Department of Information Technology

Sri Lanka Institute of Information Technology
Sri Lanka

January 2025

Prehistorical VR simulation as an educational content

R25-056

Project Proposal Report

Waynath S.P.K | IT21803420

B.Sc. (Hons) Degree Information Technology Specializing in Interactive Media

Department of Information Technology

Sri Lanka Institute of Information Technology
Sri Lanka

January 2025

Declaration Page of Candidates and Supervisor

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Group Member Name	Student ID	Signature
Waynath S.P.K	IT21803420	Kisura

The above candidates are carrying out research for the undergraduate Dissertation under my Supervision

………………………………………….   ……..…………………

Signature of the Supervisor: Date:

(Mr. Ishara Gamage)

Abstract

This study presents the development of a Virtual Reality (VR) educational platform enhanced with an AI-driven virtual guide designed to support the teaching of prehistoric studies, with emphasis on the Mesozoic era. The system enables learners to explore immersive simulations of ancient ecosystems while interacting with a conversational AI companion powered by natural language processing (NLP) and local inference models. Through real-time dialogue, spatial awareness, and adaptive responses, the guide personalizes the learning experience, offering contextual explanations about species behavior, habitats, and evolutionary dynamics. By addressing the limitations of static educational tools and traditional museum exhibits, the platform fosters active engagement, critical thinking, and deeper knowledge retention. The novelty of this component lies in its integration of VR immersion, spatially aware AI, and natural conversation, delivering an accessible and interactive educational solution that bridges the gap in prehistoric content delivery.

Keywords: Virtual Reality, Spatial Awareness, Conversational AI, Natural Language Processing, Prehistoric Education

Contents

List of Abbreviations

Abbreviation	Description
AI	Artificial Intelligence
NLP	Natural Language Processing
VR	Virtual Reality

1. Introduction

I. Background and Literature Review

The study of the Mesozoic era and its ecosystems provides critical insights into Earth's evolutionary history, biodiversity, and species' behavioral adaptations. Understanding how dinosaurs and other prehistoric organisms interacted with their environments not only deepens scientific knowledge but also offers valuable educational lessons in ecology, adaptation, and survival strategies. However, conventional methods of prehistoric education—such as textbooks, documentaries, and static museum exhibits—are often limited in their ability to deliver interactive and engaging learning experiences. These one-way communication methods restrict curiosity-driven exploration and make it difficult for learners to grasp the complexity of ancient ecosystems.

Recent advances in digital technologies, particularly **Virtual Reality (VR)** and **Artificial Intelligence (AI)**, present new opportunities to overcome these limitations. VR enables learners to be immersed in simulated prehistoric environments, while AI provides adaptive, conversational interactivity that transforms passive exploration into dynamic engagement. By combining these technologies, it becomes possible to create a **virtual guide**d AI-driven companion capable of spatial awareness, natural language interaction, and contextualized explanations. Such a guide can track a user's position, recognize nearby exhibits, and provide tailored, real-time information, significantly enhancing the learning process.

The integration of VR and AI in education has already shown promise in domains such as STEM learning, medical training, and language acquisition, where immersive and interactive experiences improve comprehension and retention. Studies highlight that **context-aware VR systems** [1], **distributed intelligent agents** [2], and **spatially guided navigation techniques** [3] can greatly improve user engagement and reduce disorientation. In the museum domain, mixed-reality agents like *MiRA* [4] and knowledge graph–driven chatbots such as *MuBot* [5] have demonstrated the potential of intelligent companions for cultural heritage education, though they often lack scalability or spatial immersion. Furthermore, VR-based STEM research confirms that immersive environments enhance spatial reasoning and problem-solving skills [6], strengthening the argument for their application in prehistoric studies.

This literature review indicates a growing academic interest in combining VR and AI for interactive learning, but also reveals a significant gap in applying these innovations to prehistoric education. Developing an AI-driven, spatially aware virtual guide for Mesozoic VR environments addresses this gap, offering learners an engaging and adaptive platform to explore ancient species and ecosystems through immersive, conversational interactions.

II. Research Gap

Despite significant advancements in **Virtual Reality (VR)** and **Artificial Intelligence (AI)** for education, there remains a clear gap in their integration for prehistoric studies, particularly in simulations of the **Mesozoic era**. Current VR-based educational tools primarily rely on static visualizations and passive exploration, which limit user engagement and fail to deliver interactive, inquiry-driven learning experiences. While some VR simulations allow exploration of reconstructed environments, they lack intelligent companions capable of **real-time, contextual, and adaptive interaction**.

Furthermore, existing AI-driven educational systems are often designed for **structured learning domains** such as language training or tutoring, rather than open-ended historical exploration. This restricts learners from engaging in curiosity-driven inquiry, where they can ask spontaneous questions and receive immediate, context-aware responses. Traditional museum exhibits and static content further exacerbate this gap, offering little scope for **personalized, immersive engagement**.

Another key gap lies in the **absence of AI-driven problem-solving mechanisms** within prehistoric VR experiences. Current simulations do not allow users to engage in dynamic discussions about ecosystems, species behavior, or evolutionary processes, leaving many questions unanswered. This shortcoming reduces opportunities for **critical thinking and active learning**.

Finally, **adaptability to diverse learners** is missing in current systems. Existing VR applications do not adjust explanations based on a learner's prior knowledge, age group, or expertise level, limiting accessibility for both novices and advanced users.

Thus, there is a pressing need for a **spatially aware AI Virtual Guide** that bridges these gaps by enabling users to:

1. Engage in natural language conversations within immersive Mesozoic environments.
2. Receive **real-time, context-specific explanations** based on their virtual location and actions.
3. Participate in **guided problem-solving discussions** to explore ecosystems and species behavior.
4. Experience a **personalized, adaptive learning journey** tailored to different levels of expertise.

By addressing these gaps, the proposed system aims to transform prehistoric education from a passive, observational process into an **interactive, adaptive, and inquiry-driven learning experience**.

Identified Gap	Existing Problem	Proposed Solution	Expected Impact
Lack of interactive AI-driven guides in prehistoric VR simulations	Current VR tools focus on static visuals and passive exploration, limiting learner engagement.	Develop a **spatially aware AI guide** that engages users in natural language dialogue within Mesozoic VR environments.	Makes prehistoric education more **interactive and immersive**, encouraging active participation.
Absence of real-time, contextual responses	Existing VR simulations lack context-aware AI to provide location-specific explanations.	Implement **NLP-based conversational AI** (LLaMA3.1 via Ollama) with spatial awareness to tailor responses to user position and nearby exhibits.	Enables learners to receive **personalized, context-specific feedback**, improving understanding and knowledge retention.
Limited problem-solving mechanisms	Current tools provide no AI-driven problem-solving or guided inquiry, leaving users with unanswered questions.	Integrate an **AI problem-solving module** that supports guided discussions on ecosystems and species behavior.	Promotes **critical thinking and inquiry-based learning**, enhancing problem-solving skills.
Lack of adaptability to user needs	Simulations do not adjust explanations to suit different age groups or knowledge levels.	Design the AI to **adapt explanations dynamically** based on user expertise and learning goals.	Makes prehistoric education **inclusive** and accessible for diverse learners, from students to researchers.

III. Research Problem

Traditional educational approaches to prehistoric studies, such as textbooks, documentaries, and museum exhibits, often fail to provide immersive and interactive learning experiences. While Virtual Reality (VR) has been employed to visualize prehistoric environments, most existing simulations remain **passive**, offering only static reconstructions without intelligent, adaptive guidance. This results in limited engagement and minimal opportunities for real-time, inquiry-based learning.

The absence of an **AI-powered virtual guide** in prehistoric VR simulations creates a major gap: learners can explore environments visually but cannot ask **context-aware questions** or receive **real-time, verbal explanations**. This shortcoming restricts curiosity-driven learning, reduces knowledge retention, and limits the development of problem-solving skills in educational contexts.

Furthermore, current AI applications in education primarily support **structured, domain-specific training** (e.g., language learning, tutoring), rather than **open-ended exploratory learning** within immersive environments. Without conversational AI that adapts to different knowledge levels and provides **context-specific insights** into biodiversity, evolution, and ecological interactions, learners are unable to fully grasp the complexity of Mesozoic ecosystems.

Thus, the core research problem is the **lack of an adaptive, spatially aware AI guide** in prehistoric VR education. This gap restricts learners from engaging in meaningful, interactive, and personalized exploration of ancient ecosystems. Addressing this problem requires the integration of **natural language processing (NLP), conversational AI, and VR immersion** to transform passive prehistoric simulations into dynamic, context-aware, and inquiry-driven learning experiences.

2. Objectives

Main Objectives

1. To develop a spatially aware AI-powered virtual guide for prehistoric education in VR.
2. To enhance engagement, interactivity, and learning outcomes in Mesozoic simulations.

Specific Objectives

1. Implement an AI chatbot using Llama3.1 via Ollama for real-time dialogue.
2. Integrate Glow-TTS to provide natural and engaging voice output.
3. Develop spatial awareness mechanisms to detect user position, orientation, and nearby exhibits.
4. Evaluate educational effectiveness through user testing and feedback.
5. Ensure inclusivity for students, educators, and museums through adaptive learning levels.

3. Methodology

3.1.1 Development Process

This research component will follow a structured software development lifecycle (SDLC) approach, including planning, design, implementation, testing, and deployment.

Figure 1Software Development Life Cycle

3.1.2 Feasibility Study

A feasibility analysis will assess the technical, economic, and operational viability of integrating AI-driven conversational agents within VR environments.

3.1.3 Requirement Gathering and Analysis

Data collection methods such as literature review, expert consultations, and user feedback will inform system design.

3.1.4 Data Set

The dataset comprises information of prehistoric species, the environment that the species have inhabited, fossil evidence, user queries and ai responses will be used for AI training.

3.1.5 Implementation

The system will be developed using VR development frameworks, AI NLP models, and various open-source technologies.

3.1.6 Testing

The system will undergo functional, usability, and performance testing to ensure reliability and effectiveness.

System Architecture

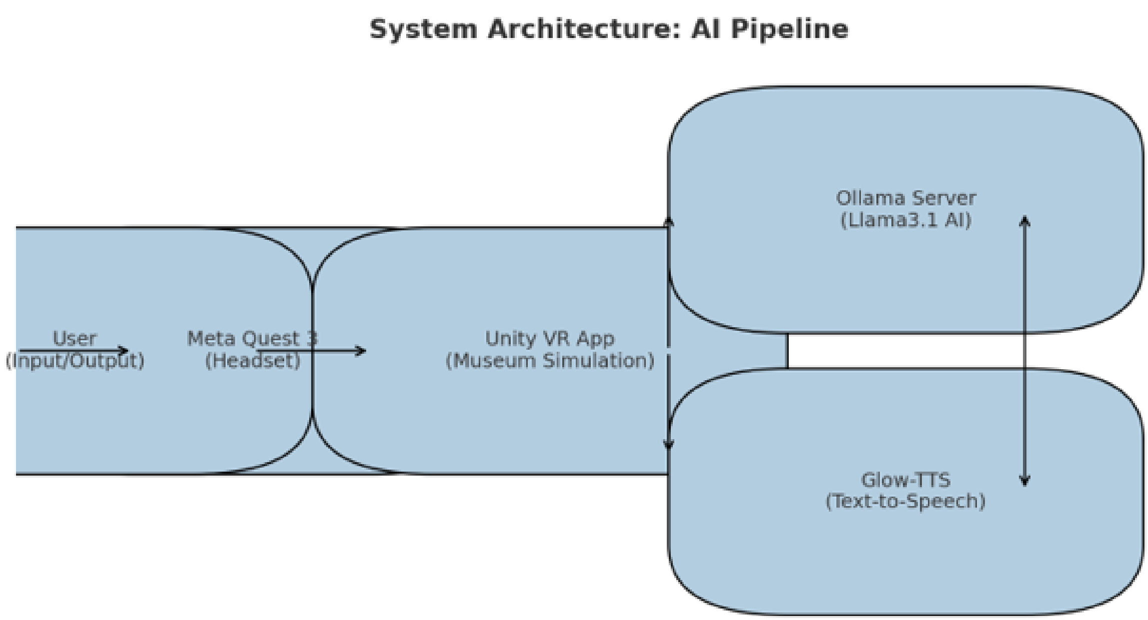

Figure 2 System Architecture

Spatial Awareness Workflow

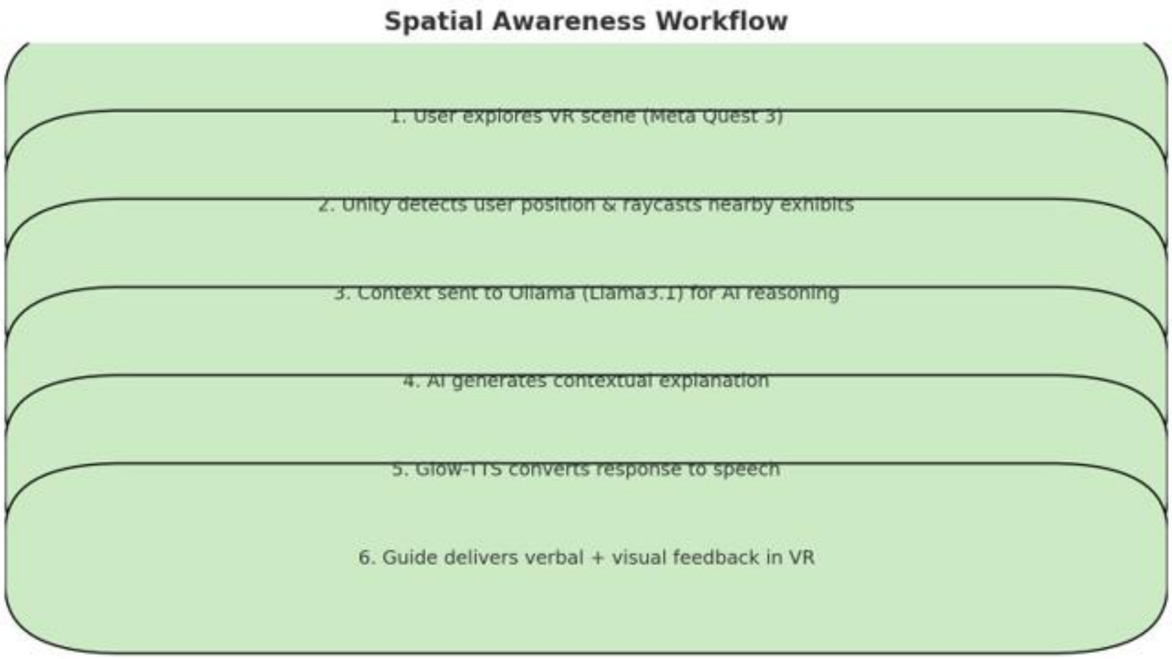

Figure 3 Spatial Awareness Workflow

4. Project Requirements

User Requirements

1. Users should be able to interact with the AI Virtual Guide through voice commands.
2. The system should provide real-time verbal responses using a prehistoric knowledge dataset trained on species, ecosystems, and fossil evidence.
3. Users should be able to explore and navigate Mesozoic environments in VR using the Meta Quest 3 headset.
4. The AI Virtual Guide should deliver context-aware explanations based on user location, orientation, and nearby exhibits in the virtual environment.
5. The system should offer an engaging and immersive learning experience, enhancing curiosity-driven exploration.
6. Users should have the ability to repeat questions and receive either consistent or varied responses depending on the query.
7. The system should support multiple difficulty levels (e.g., beginner, intermediate, expert) to accommodate learners of different backgrounds.
8. The Virtual Guide should be accessible for both educational institutions and individual learners, ensuring usability in classrooms, museums, and self-study contexts.

Software Requirements

1. **VR-compatible software** (Unity3D with Meta XR SDK) to render immersive prehistoric environments.
2. A **local knowledge database** or Knowledge Graph (with optional cloud support) to store and retrieve prehistoric data.
3. **AI/ML model** (LLaMA 3.1 via Ollama) fine-tuned on prehistoric datasets for conversational intelligence.
4. **Glow-TTS** or equivalent text-to-speech system for natural voice output.
5. **User Interface (UI)** for configuration, accessibility settings, and progress tracking.
6. **Internet connectivity (optional)** for updates, dataset expansion, and collaborative learning features.

Functional Requirements

1. The AI Virtual Guide should **process and respond to spoken user queries accurately** using natural language processing (NLP).
2. The system should **recognize speech input** and provide **audible, natural-sounding responses**.
3. The AI should provide **spatially contextual responses**, adapting explanations based on exhibits or scenes near the user.
4. The system should enable **guided problem-solving interactions**, allowing learners to ask reasoning-based questions (e.g., predator-prey dynamics).
5. The AI should allow **personalized adaptation**, adjusting explanations based on user expertise level or age group.

Non-Functional Requirements

1. The system should provide a seamless, natural user experience with minimal latency in responses.
2. The AI should maintain high accuracy in speech recognition and contextual reasoning.
3. The platform should be scalable, allowing future integration of larger AI models and knowledge graphs.
4. The system should be accessible to users of varying technological proficiency, with intuitive controls and simple onboarding.
5. The application should run efficiently on the Meta Quest 3, without requiring excessive additional hardware.
6. The guide should follow educational standards to ensure reliability, factual accuracy, and inclusivity.

5. Gantt Chart

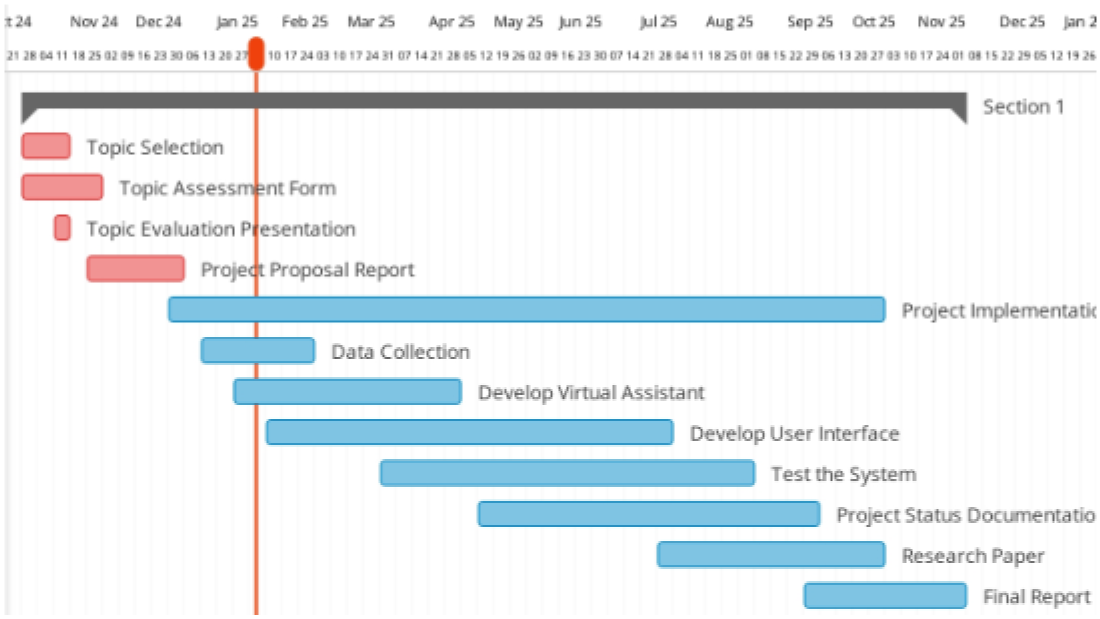

Figure 4Gantt Chart

6. Work Breakdown Chart

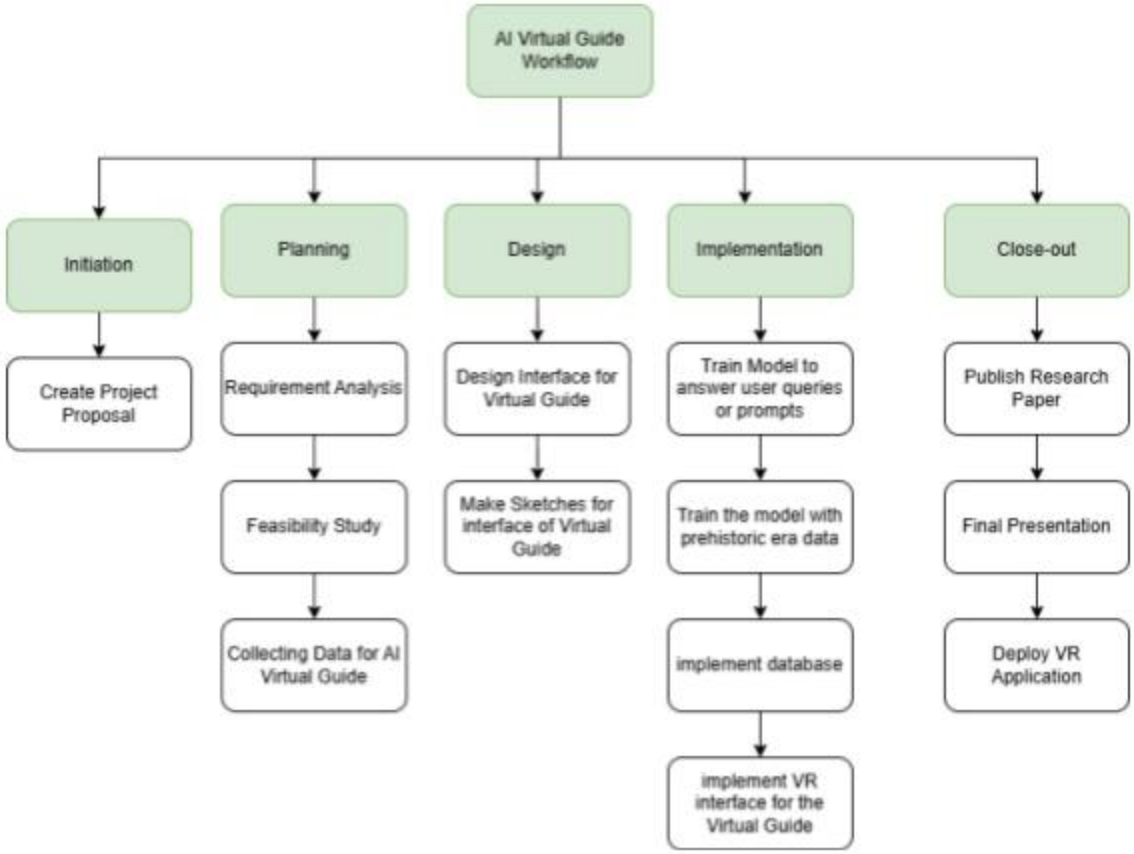

Figure 5 Workbreakdown Chart

7. Budget

Task	Cost
Travelling	5000
Deployment Cost	10000
Total	15000

8. Commercialization

Target Audience

- Educational Institutions
- Museums
- Students
- History & Archaeology Enthusiasts
- VR Learning Platforms

Market Space

- No prior technological knowledge required
- Suitable for university students
- Enhances engagement and accessibility in prehistoric education

References

[1] P. Pavani et al., *A Context-Aware Platform for Mobility in Immersive Environments*, 2022.

[2] A. Celentano et al., *Agents for Distributed Context-Aware Interaction*, 2021.

[3] A. Kanthasamy, *Enhancing Spatial Awareness and Navigation in Virtual Reality Environments*, University of Jaffna, 2023.

[4] T. Holz et al., *Mixed Reality Agents as Museum Guides*, Proc. AAMAS, 2006.

[5] S. Varitimiadis et al., *"Talking" Triples to Museum Chatbots*, HCI International (LNCS 12215), pp. 281–299, 2020.

[6] E. Thompson, *Analyzing the Impact of Virtual Reality on Spatial Awareness in STEM Education*, *RRJ Educ Stud.*, vol. 10, issue 3, Sept. 2024