Region - Educational Research and Reviews, 2025, Volume7, Issue1
DOI: 10.32629/rerr.v7i1.3327
ISSN Online: 2661-4634
ISSN Print: 2661-4626

Construction and implementation of virtual learning scenarios for terrain and landform based on HTC Vive

Manjin XU, Hanchu HU

College of Education, Zhejiang Normal University, Jinhua 321004, China

Abstract: Traditional geography teaching faces challenges like complex content, limited field observation, and safety risks during outdoor activities. This study developed a VR-based terrain and landform learning system using HTC Vive and Unity 3D, enhancing teaching quality, deepening students' geographic understanding, and showing great potential for broader educational applications.

Key words: HTC Vive; virtual reality; terrain and landform; spatial teaching

1 Introduction

The teaching of terrain and landform often relies on textbooks, making content abstract and hard to grasp, resulting in less effective outcomes. Outdoor field teaching, essential for geography learning, faces challenges such as unpredictable weather, large observation areas, time limits, and safety risks. While some teachers use whiteboards or videos as supplements, most software is restricted to tablet devices like phones or computers, limiting learning effectiveness [1]. VR technology offers a solution by creating diverse terrain and landform scenarios in a virtual space.

Geography learning benefits significantly from field observations. Bower found that children with outdoor learning experiences can better explain geographic phenomena [2]. However, organizing such lessons is time-intensive, making simulation software a practical teaching aid. Huang Hui noted that software like Celestia and Stellarium still struggles due to the limitations of tablets [3]. Zhao Wenbo introduced a VR-supported geography teaching model, significantly improving outcomes [4]. VR technology surpasses tablet device constraints, providing experiences closer to real outdoor environments, boosting learning efficiency [5].

This study developed a VR system for secondary school terrain and landform education, utilizing HTC Vive devices. The system includes three distinct landform scenarios from various locations and times. Users interact via headsets and controllers, move freely, and trigger terrain descriptions through gazing or active clicking, offering an innovative approach to geography education.

2 System design

2.1 Requirement analysis

Traditional terrain and landform teaching relies on flat representations, making it hard for students to visualize features and formation processes, leading to abstract and less effective learning. VR technology, combined with HTC Vive, overcomes these limitations by simulating realistic scenarios, allowing students to explore diverse terrains as if they were outdoors. Through gaze control, students can observe terrain, access geographic information, and understand geological changes, significantly enriching their learning experience and enhancing outcomes.

2.2 System design

The system uses HTC Vive to implement various interactions. As shown in Figure 1, the architecture consists of three core layers.

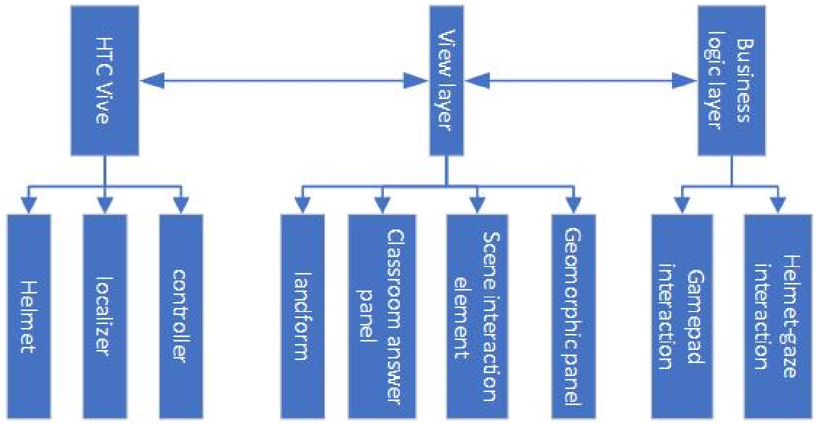

Figure 1. The three core layers of the architecture

HTC Vive interaction Layer: Manages interactions with the HTC Vive device, including headset display, spatial positioning and controller functionality.

Visual display layer: Dynamically switches content displayed based on user instructions, offering diverse visual experiences.

Business processing layer: Acts as the central hub, interpreting user inputs and triggering scene changes or textual information in response.

When users log in via HTC Vive, the system activates the visual layer, which responds to user interactions to achieve scene switching and dynamic information display.

2.3 Functional design

The terrain and landform virtual reality system comprises four main components: character movement, learning scenarios, quiz and test systems, and system settings.

Scene switching system: activated by pressing the side button on the HTC Vive controller. A scene-switching panel appears, allowing users to select locations and seasons via laser pointer to navigate to the corresponding scenarios.

Quiz and test system: Users press the trigger button on the controller to answer questions displayed on a virtual blackboard. Questions are sourced from a local database, and users′ answers and learning data are stored in the database.

System settings: Activated by pressing the side button on the controller, enabling users to adjust basic settings such as sound volume.

2.4 Interaction design

The system was developed using Unity 2020.2.7f1c1. Multiple projects were created and edited for different locations, then packaged into a single project. Code was added to scenes, and a directly executable program was exported.

Upon entering the system, users appear in the main 3D space. Using the controller and headset, users send interaction commands to the display layer, which are processed through the service layer and data layer. This will change the displayed visuals, achieving interactive effects.

3 System development and application

3.1 Development environment

3.1.1 Hardware

Terrain and landform learning system based on HTC Vive has high requirements on hardware. To ensure high visual fidelity and reduce motion sickness, the HTC Vive Pro was chosen [6].

3.1.2 Software

The system runs on the SteamVR platform with HTC Vive Pro hardware. Developed in Unity, it integrates the SteamVR Plugin for headset synchronization via CameraRig. Visual Studio handles scripting, while 3ds Max is used for modeling.

3.2 Key technology

(1) 3D Modeling. The system features Yadan, Karst, and Danxia landforms, showcasing the initial forms, transformations, and final stages. Terrain, vegetation, and skies were modeled with Unity 3D's terrain editor and 3ds Max, with skyboxes creating immersive environments [7].

(2) Virtual engine technology. Unity 3D was selected for its visual editing and cross-platform support. Key systems include terrain, physics, shader, and particle [8]. The plugin integrated Unity 3D, HTC Vive, and SteamVR for seamless VR project execution.

(3) The system employs HTC Vive for immersive interactions. Users navigate scenes via headset movement and controllers. A gaze-based system in Unity triggers animations and interactive panels, while controllers enable switching between first-person and third-person views for varied observations.

3.3 Operation effect

Upon entering the system, users start in the main 3D space, where they can adjust settings using the controller. A location selection panel offers Yadan, Karst, and Danxia options, while a time selection panel allows users to choose from initial, transitional, or final landforms.

In a scenario, users can observe terrain features and interact with objects by maintaining stable gaze. Interaction triggers animations, which display descriptions for learning purposes. Once users complete their observations, they can switch to other scenarios for continued learning.

After completing the learning process, users return to the initial scene for testing. Test questions appear on a blackboard in the classroom, and answers are submitted via the controller. All response data is uploaded to the database.

4 Conclusion

This study explored the application of VR technology in education and designed a VR-based terrain and landform teaching system to address limitations in secondary school geography education. By enhancing sensory experiences and deepening cognitive engagement, the system provides reliable teaching assistance for geography educators. It also serves as an experimental platform for VR teaching research, demonstrating broad application potential and revolutionizing secondary school geography education.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Carrion B, Gonzalez-Delgado CA, Mendez-Reguera A, et al. 2021. Embracing: User acceptance of virtual settings for learning. *Computers and Electrical Engineering*, 93.

[2] Bower CA, Liben LS. 2021. Can a domain-general spatial intervention facilitate children's science learning?

Child Dev, 92(1): 76-100.

[3] Huang H, Tao SS. 2018. Comparative Study of Celestia and Stellarium in geography teaching. *Geography Teaching,* 16: 53-57.

[4] Zhao WB, Sun MP. 2024. Exploration of innovative geography teaching supported by VR. *Middle School Geography Teaching Reference*, 26: 48-51.

[5] Bos D, Miller S, Bull E. 2022. Using virtual reality (VR) for teaching and learning in geography. *Journal of Geography in Higher Education*, 46(3): 479-488.

[6] Cheng P, Yan JL. 2019. Visualization of Virtual Scene Based on HTC Vive Interactive System. IEEE 4th International Conference on Computer and Communication Systems.

[7] Zhang Q. 2021. Virtual reality modeling of garden geography and geology based on 3D modeling technology. *Journal of Physics: Conference Series*, 1952(2).

[8] Wei YM. 2022. Design and development of IVR system using Unity3D and 3ds Max. *China Educational Technology Equipment*, 6: 30-32.

About the author

Xu Manjin (1999-) male, Han nationality, Hangzhou, Zhejiang, master's degree in virtual reality.

Hu Hanchu (2003-) female, Han nationality, Wenzhou, Zhejiang, undergraduate majoring in virtual reality.