11th International Conference of the Immersive Learning Research Network
Practitioner Proceedings iLRN2025
DOI: https://doi.org/10.56198/ewzbvs07

Development of XR Simulation for Geography Learning Based on LXD

Kukhyeon Kim[1] and Jeeheon Ryu[1]

[1] Chonnam National University, Gwangju city, South Korea
kukhyeon8@gmail.com

Abstract. This iLEAD paper aimed to design and develop an extended reality (XR) learning environment based on Learning Experience Design to enhance learners' understanding. Recognizing the importance of aligning XR environments with educational theories for effective implementation, this study employed a Learning Experience Design approach, addressing the cognitive, emotional, behavioral, and technical aspects of learning. The focus was on geographic content, specifically Köppen's climate classification of the environment, aimed at enhancing understanding through physical interactive learning. This study demonstrates how this XR simulation was designed and developed to improve learners' interactive learning experiences with virtual objects. It emphasizes the significance of incorporating educational theories into XR design to optimize learning outcomes and proposes future research focused on various learning experiences.

Keywords: XR Simulation, Geography Simulation, Learning Experience Design, Learning Experience, Immersive Learning.

1 Introduction

The purpose of this study is to design and develop an extended reality (XR) learning environment based on Learning Experience Design (LXD) and to analyze learners' experiences. As XR technology has advanced, XR-based learning environments are being applied across various educational fields. XR encompasses technologies that utilize virtual spaces for learning, such as Virtual Reality, Augmented Reality, and Mixed Reality [1]. In disciplines such as geography, medicine, science, nursing, arts, and vocational education, XR simulations have been developed, and their effectiveness has been verified [2-3]. XR learning environments connect virtual reality with the real world, enabling learners to interact with virtual objects, thereby enhancing immersion and the sense of presence [4]. However, despite these positive effects, learning contexts grounded in educational theoretical foundations to ensure that XR learning environments are effectively utilized according to educational contexts and objectives need to be applied [5]. LXD is an instructional design theory that views the overall experiences learners have during the learning process as integral to achieving learning outcomes [6-7]. From this perspective, the design and configuration of learning experiences play a critical role in shaping effective learning environments [8]. Building on this foundation, the present study focuses on designing and developing an XR learning environment guided by LXD principles and conducting interviews with 13 participants to identify their experiences. Specifically, it explores the creation of XR-based learning simulations informed by LXD to enhance the learning experience.

2 Literature Review

LXD provides a framework for designing digital learning environments that integrate human-computer interaction, user-centered design, and pedagogical theories to enhance teaching and learning experiences. LXD emphasizes creating balanced and effective learning outcomes by addressing cognitive, affective, behavioral, and technological dimensions [9-11]. The cognitive domain focuses on building learners' knowledge and understanding; the affective domain emphasizes shaping learners' attitudes, values, and emotions; the behavioral domain concentrates on developing physical skills and actions; and the technological domain focuses on human-

©2025 Immersive Learning Research Network

computer interaction [12]. This multidimensional approach assists learners in better-comprehending content and actively engaging in the learning process.

In XR environments, interface design is critical for fostering meaningful interactions between learners and virtual content. LXD-based XR simulations allow learners to explore and interact with virtual objects, such as resizing, rotating, or observing them in 3D, providing more engaging and diverse learning experiences, compared to 2D visuals. This integrated approach not only enhances comprehension but also promotes active learner participation, ensuring a well-rounded and impactful educational experience.

3 Design & Development

3.1 Learning Objectives

This study addresses Köppen's climate classification as a key learning content in world geography. The target users of this simulation are indivisual who have a general interest in understanding global climate system. Two tasks were developed to address both foundational concepts and advanced analytical skills regarding Köppen's climate classification.

The first task focuses on understanding the concept of the Sahara climate. Through the simulation, learners can explore various elements of the Sahara climate, such as temperature, precipitation, and wildlife.

The second task involves analyzing the concepts of Köppen's climate types, providing an in-depth learning experience by analyzing and comparing various climate characteristics. Learners analyze and compare data related to temperature, precipitation, and vegetation, developing analytical skills by categorizing Köppen's climate classification into a table format. This task moves beyond rote memorization, requiring learners to comparatively analyze Köppen's climate types based on data. To enhance understanding, learners are provided with 3D models representing Köppen's climate types, allowing them to visually grasp the distinctive features of each climate through interactive manipulation.

3.2 Interface Design

The interface of the XR simulation was designed based on LXD and structured around the cognitive, emotional, behavioral, and technical dimensions.

Cognitive Dimension. This dimension focuses on instructional aspects that influence learners' acquisition and comprehension of knowledge. Key considerations include how learning materials are presented and how feedback is provided for specific tasks. The design emphasized structuring audiovisual content, organizing tasks effectively, and delivering feedback on performance.

Affective Dimension. This dimension addresses factors impacting learners' attitudes, values, interests, motivation, and enjoyment, which are part of positive emotions. Positive reactions to learners' performance, such as affirmations or supportive feedback, play a critical role in fostering positive effects.

Behavioral Dimension. This dimension connects learning with physical actions to encourage active participation and engagement. It involves tasks in which learners express their understanding through actions, such as completing hands-on activities or performing procedural tasks in the simulation environment.

Technical Dimension. This dimension focuses on interactions between learners and the computer system. In digital learning environments, factors such as the intuitiveness of interface icons, the positioning of interface elements, selection speed, and auditory feedback were carefully considered and applied.

3.3 Development Tool

To develop the XR simulation, the 3D game engine (Unity) was utilized. The XR simulation was deployed on the HoloLens 2 device, enabling an immersive and interactive learning experience.

3.4 Interview

A total of 13 participants voluntarily participated in interviews regarding their experiences with XR simulations. The participants had an average age of 21.4 years and included 4 males and 9 females. Their academic backgrounds were diverse, with three participants from education, three from natural sciences, four from engineering, two from social sciences, and one from the humanities. The interview questions focused on subjective perceptions of factors that facilitated or hindered learning. Each interview lasted an average of approximately 13 minutes.

4 Results

4.1 Development

Fig. 1 illustrates the final implementation of the XR simulation for Task 1. Learners can directly manipulate 3D objects, such as huts, using their hands. Fig. 2 depicts the final implementation of the XR simulation for Task 2. Learners can manipulate 3D objects, such as Köppen climate-type cubes, using their hands. The learning objective of Task 2 in the XR simulation is to understand the characteristics of climate types based on Köppen's climate classification. Learners achieve this by moving climate-type cubes, categorized by temperature and precipitation, onto a learning board to distinguish the features of Köppen's climate types. Examining the interface of Task 1 and Task 2 in the XR simulation based on cognitive, affective, behavioral, and technical dimensions reveals the following:

Cognitive Dimension: This dimension facilitates the understanding and acquisition of knowledge. In the XR simulation, it is implemented through interfaces that deliver conceptual knowledge. Examples include learning content boards, additional learning material boards, and 3D assets in the geography XR simulation.

Affective Dimension: This dimension influences learners' values, enjoyment, motivation, and interest. It includes engaging visual 3D object materials, positive feedback (e.g., auditory cues for correct answers, messages for correct responses), and emotional support statements such as "It's okay, try again!" The user interface design of the XR simulation also contributes to the affective domain.

Behavioral Dimension: This dimension involves the acquisition of skills and the physical expression of knowledge. The XR simulation implements this through interactions such as moving 3D objects and clicking submission buttons.

Technological Dimension: This dimension includes natural interaction between the computer and the user in an XR environment, minimizing discomfort. To enhance usability, the user interface was designed with primary learning materials positioned centrally for easy viewing. Supplementary information was placed on the right side, utilizing intuitive icons such as a magnifying glass for accessibility. Additionally, 3D objects were programmed to respond instantly to user inputs, ensuring smooth movements and feedback to prevent inconsistencies.

Fig 1. Task 1.

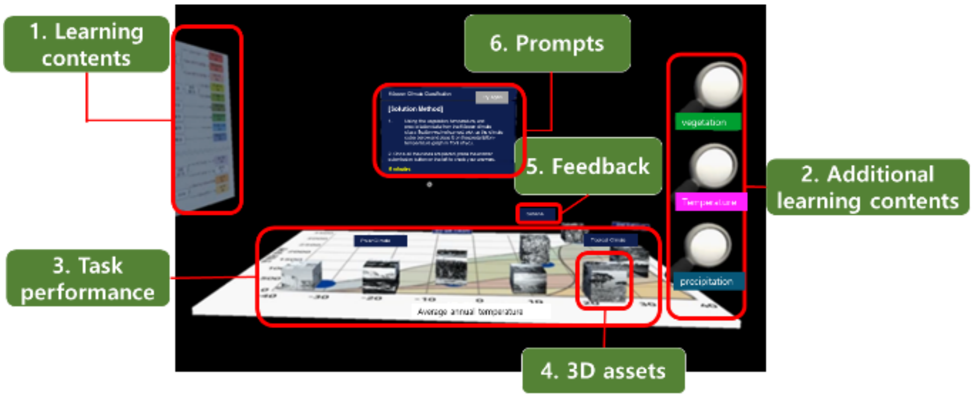

Fig 2. Task 2.

4.2 Interview

Table 1 summarizes the interviews with 13 participants, categorizing the factors that facilitated and hindered learning.

Table 1. Facilitating and inhibiting factors for learning.

Heading level	Facilitating factors	Inhibiting factor
Content	- Direct manipulation - Opportunities for repeated practice - Temporary correct/incorrect feedback - Highly immersive interactions - Appropriate visual and auditory stimuli	- Environmental distractions - Limited field of view

5 Discussion and Conclusion

This study designed and developed an XR simulation based on LXD, and based on the results, the following insights were identified. The XR simulation developed in this study can be effectively integrated into the high school geography curriculum, offering an innovative approach to teaching complex concepts such as Köppen's climate classification. LXD was applied to the design and development process, leveraging the unique characteristics of XR technology that integrates virtual objects with real-world spaces. This integration provides learning materials that engage auditory, visual, and spatial senses, highlighting the critical role of learner-computer interactions in the learning process [6-8]. To fulfil this objective, the XR simulation was designed with an integrative perspective, incorporating cognitive, affective, behavioral, and technical dimensions, which positions this study as foundational research in XR simulation design and development. Additionally, this research outlined a systematic process for the analysis, design, and development of XR simulations, detailing a step-by-step framework that serves as a reference for future researchers and developers of XR-based educational tools.

To further strengthen the applicability of this study, future research could explore testing the XR simulation with a broader demographic, including learners with diverse educational backgrounds or varying levels of technological proficiency. Additionally, investigating how educators and instructional designers can integrate XR simulations into existing curricula across different subjects, such as biology or history, could enhance the broader applicability of this approach. Expanding the scope of XR-based learning beyond geography would provide valuable insights into its effectiveness in various educational contexts, reinforcing the potential of XR technology as a versatile and scalable tool for immersive learning.

Acknowledgements

This work was supported by the Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (NO.2022-0-00137, XR User Interaction Evaluation and Employing Its Technology)

References

1. Meccawy, M.: Creating an immersive xr learning experience: A roadmap for educators. Electronics 11(21), 3547 (2022).
2. Railean, E. A., Valeyeva, N. S., Kupriyanov, R. V.: Psychological pedagogy for extended reality in STEMx education. In: 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), pp. 976-979. IEEE, (2020).
3. Okanovic, V., Ivkovic-Kihic, I., Boskovic, D., Mijatovic, B., Prazina, I., Skaljo, E., Rizvic, S.: Interaction in extended reality applications for cultural heritage. Applied Sciences 12(3), 1241 (2022).
4. Tang, Y. M., Ng, G. W. Y., Chia, N. H., So, E. H. K., Wu, C. H., Ip, W. H.: Application of virtual reality (VR) technology for medical practitioners in type and screen (T&S) training. Journal of Computer Assisted Learning 37(2), 359-369 (2021).
5. Choi, S., Lee, J., Shin, Y.: Applications and effects of XR in education for XR contents design. Journal of Digital Contents Society 23(9), 1757-1766 (2022).
6. Jahnke, I., Schmidt, M., Earnshaw, Y., Tawfik, A. A.: Theoretical considerations of learning experience design. EdTech Books, (2022).
7. Wong, J. T., Bui, N. N., Fields, D. T., Hughes, B. S.: A learning experience design approach to online professional development for teaching science through the arts: Evaluation of teacher content knowledge, self-efficacy and STEAM perceptions. Journal of Science Teacher Education 34(6), 593-623 (2023).
8. Schnepp, J, Rogers, C.: A practical approach to Learner Experience Design. International Journal of Teaching and Learning in Higher Education 34(1) 161-169 (2022).
9. Hoque, M. E.: Three domains of learning: Cognitive, affective and psychomotor. The Journal of EFL Education and Research 2(2), 45-52 (2016).
10. Rovai, A. P., Wighting, M. J. , Baker, J. D., Grooms, L. D.: Development of an instrument to measure perceived cognitive, affective, and psychomotor learning in traditional and virtual classroom higher education settings. The Internet and Higher Education 12(1), 7-13 (2009).
11. Schmidt, M., Tawfik, A. A., Jahnke, I., Earnshaw, Y.: Learner and user experience research: An introduction for the field of learning design & technology. EdTech Books (2020).
12. Larkin, B. G., Burton, K.J.: Evaluating a case study using Bloom's taxonomy of education. Aorn Journal 88(3) 390-402, (2008).