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Towards IPB Immersive Field Trip Platform: Virtual Reality Field Trip to Introduce Digital Village Ecosystem to Computer Science Students

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ABSTRACT

The virtual field trip format offers several advantages over a fully three-dimensional world, including its ease and cost-effectiveness in creation and development. By utilizing a 360 camera, capturing images becomes convenient, portable, and viable even in remote regions. With the amount of activity involving students and agricultural society, the potential for integrating these field trip experiences into a learning experience is significant in IPB University. Not only it able to help students understand the context before doing the actual field trip, it also able to improve their empathy to the society introduced through the virtual field trip. This research aims to present the development of a virtual reality tour to introduce digital village ecosystem to computer science students and measure its presence among the students. The 360 scenes were captured during a visit to a digital village in West Java, and an immersive learning plan was devised to introduce the digital village ecosystems. The learning path was designed based on the cone of learning principle. To evaluate the effectiveness of the virtual reality system, presence questionnaires were administered, a knowledge test was conducted, and interviews were carried out with 22 students. Research indicates that the virtual field trip successfully introduced one digital village ecosystem in Cibodas, West Java Province. Students were able to explore the village site, learn about the digital village ecosystem, and provide valuable feedback. The presence questionnaire yielded a score of 5.49 out of 7, indicating a positive immersive experience. The two are of improvements are Involvement (4.96 of 7.00) and Distraction Factor (5.20 of 7.00). The interviews identified areas for improvement, such as enhancing content quality and increasing natural interaction within the system. In conclusion, this research has laid the foundation for the IPB Immersive Field Trip Platform by developing a virtual field trip that introduces computer science students to a digital village ecosystem. The findings demonstrate promising results and provide insights for further refinement of the platform.

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1. Introduction

IPB University is known for organizing more than 100 field trips and expeditions annually, offering students a unique opportunity to enhance their understanding of concepts in real environments while developing empathy towards society and nature. There are an abundant number of data gathered which provide insight for both learning and research purposes in the university, especially related to biodiversity. However, the high cost associated with these trips, especially for a large number of students, poses a significant challenge to the inclusivity of the program.

Virtual reality field trips (VRFTs) have been shown to enhance performance, motivation, and knowledge retention among learners [1]. They offer a unique opportunity to understand and master complex processes through interactive and multimodal visualizations of past and future realities [2,3]. Additionally, VRFTs facilitate the development of empathy by transporting viewers to remote and inaccessible places, providing a transformative and impactful experience [4]. The interactivity, emotional engagement, and increased empathy associated with VRFTs have revolutionized the way information is accessed, creating a more effective connection with the content [5,6]. Moreover, VRFTs offer cost-effectiveness in their creation and development, making them an attractive alternative to traditional field trips [7]. By examining these advantages, this study aims to shed light on the potential of VRFTs as a learning tool within the context of IPB University's field trips and expeditions.

Hence, there is potential to utilize VRFTs to support learning in higher education. Previous research has explored this potential in pharmacology and ecotourism [8], geoscience [9], and waterworks [10] with a clear potential for scaling up. In IPB University itself, the initiative of capturing the agricultural data and presenting them in an immersive format such as [11] is integrated able with the VRFTs and will enrich the information presented in the field trip. Moreover, IPB University, [12] not only utilized the VRFTs for higher education learning but integrated them into the university museum exhibition for public education. Furthermore, the VRFTs could help to prepare non-agriculture students in IPB University often experiences challenges before doing their community services and other learning activities in rural environments [13]. When enough quantity of VRFTs is created, the university can launch an IPB Immersive Field Trip Platform to support learning in the university.

With the current strain on global food systems, one of the primary concerns of the Food and Agriculture Organization of the United Nations (FAO) is the transformation of the rural agrifood systems, including Indonesia. FAO introduced the digital village ecosystem (DVE) [14] which includes basic infrastructure, demand for digital services, supply of digital services, economic sustainability, and local ownership. Computer science students are an integral part of an effort to help the rural area to transform using digital innovations. However, they often lack understanding of the rural area situation which provides challenge and discourage them to work closely with the rural community.

The purpose of this research is to develop a minimum viable product of VRFT to introduced the digital village ecosystem to an undergraduate computer science student. The VRFT developed with a consideration to the element of multimedia cone of abstraction [15] and design element of VR for education [16]. Although a mature VRFT can be evaluated both from technology side [17] and learning side [18], this research evaluates the presence experienced by the VRFT user using subjective measurement, where user assess their experience using a research instrument [19]. Among the numerous questionnaires, two of the most popular ones are the Slater-Usoh-Steed (SUS) Questionnaire [20] and the presence questionnaire [21]. The presence questionnaire is the most cited method for measuring presence components in research and still relevant to evaluate presence in VR system [22]. It consists of 32 questions and is based on four factors: control, sensory, distraction, and realism. The presence questionnaire utilizes a seven-point scale format [19,21].

2. Methodology

The research methodology is presented in Figure 1. Firstly, a site visit was conducted in a village located in the West Java Province. The purpose of the site visit was to gather primary data and firsthand information about the current condition of the digital village ecosystem. The researchers engaged in observations, conducted interviews with villagers, and collected relevant artifacts or documents, including 360 scene using Ricoh Theta V camera, that provide valuable insights into the unique characteristics of the village.

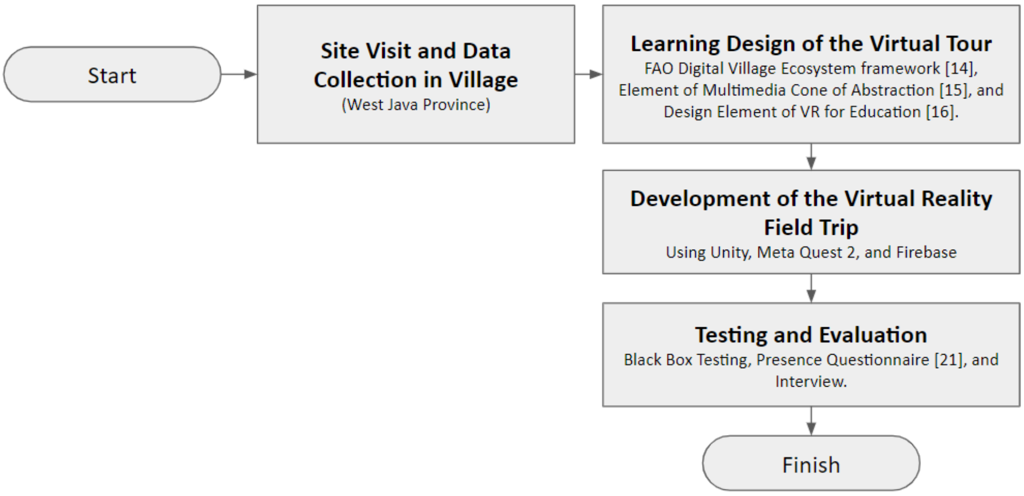


Fig. 1. The research framework and methodology used

Based on the site visit, the learning design of the virtual tour was then developed based on a combination of established frameworks and design elements. The FAO Digital Village Ecosystem framework [14] served as a core content to be delivered using virtual reality field trip, the Element of Multimedia Cone of Abstraction [15] was employed to guide the creation of engaging and informative multimedia content, while the design element of VR for education [16] helped shape the educational aspects of the virtual tour.

To bring the virtual tour to life, the researchers utilized Unity as the development platform, along with the Meta Quest 2 virtual reality headset and Firebase for data storage and retrieval. Unity provided a robust and versatile environment for designing the virtual scenes and interactions, while Meta Quest 2 offered an immersive VR experience for the participants. Firebase facilitated seamless data management and synchronization, ensuring efficient storage and retrieval of user-related data during the virtual tour, especially to store the assessment data from user.

A series of testing and evaluation methods were employed to assess the effectiveness of the virtual reality field trip. Black Box Testing was conducted to ensure the functionality and usability of the virtual tour, identifying and addressing any technical issues or bugs. The presence questionnaire, adapted from [21], was administered to measure the sense of presence and immersion experienced by the participants. The presence questionnaire translated to Indonesian, undergo face validity, and tested in a small-scale pilot testing [23] to existing commercial VR application. Based on the feedback from six participants in pilot study, we finalized the Indonesian translation which presented in Table 1.

Table 1
Indonesian translation of the presence questionnaire, adopted from English version available at [21]

No	Question (Indonesian Translation)
1	Seberapa banyak Anda bisa mengontrol aktivitas yang terjadi di lingkungan virtual?
2	Seberapa responsif lingkungan virtual sekitar anda terhadap tindakan yang anda lakukan?
3	Seberapa alami atau natural interaksi antara Anda dengan lingkungan virtual sekitar Anda?
4	Seberapa terlibat semua indra anda?
5	Seberapa besar aspek visual di lingkungan virtual melibatkan anda?
6	Seberapa besar aspek pendengaran di lingkungan virtual melibatkan anda?
7	Seberapa alami atau natural mekanisme yang mengatur gerakan Anda pada lingkungan virtual?
8	Seberapa sadar Anda terhadap peristiwa yang terjadi di dunia nyata di sekitar anda?
9	Seberapa sadar anda terhadap perangkat layar dan perangkat kontrol Anda?
10	Seberapa menarik perasaan Anda tentang objek yang bergerak di lingkungan virtual sekitar anda?
11	Seberapa tidak konsisten atau terputusnya informasi yang anda tangkap dari indra Anda?
12	Seberapa banyak pengalaman Anda di lingkungan virtual yang tampak konsisten atau mirip dengan pengalaman dunia nyata Anda?
13	Apakah Anda bisa mengantisipasi apa yang akan terjadi selanjutnya sebagai respon dari tindakan yang Anda lakukan?
14	Seberapa menyeluruh Anda bisa secara aktif mengeksplorasi dan menelusuri lingkungan virtual menggunakan penglihatan Anda?
15	Seberapa baik Anda dapat mengidentifikasi suara?
16	Seberapa baik Anda dapat mengidentifikasi sumber suara?
17	Seberapa menyeluruh Anda dapat secara aktif mengeksplorasi dan menelusuri lingkungan virtual menggunakan sentuhan Anda?
18	Seberapa menarik perasaan Anda untuk bergerak di dalam lingkungan virtual?
19	Seberapa teliti Anda dapat memeriksa atau melihat objek?
20	Seberapa baik Anda dapat memeriksa atau melihat objek dari berbagai sudut pandang?
21	Seberapa baik Anda dapat memindahkan atau memanipulasi objek di lingkungan virtual?
22	Sejauh mana Anda merasa bingung (kondisi disorientasi) pada awal sesi istirahat atau akhir sesi percobaan?
23	Seberapa terlibat Anda dalam pengalaman di lingkungan virtual?
24	Seberapa mengganggu mekanisme kontrolnya?
25	Seberapa banyak delay yang Anda alami antara tindakan Anda dan hasil yang diharapkan?
26	Seberapa cepat Anda menyesuaikan diri dengan lingkungan virtual?
27	Seberapa mahir Anda dalam bergerak dan berinteraksi dengan lingkungan virtual di akhir sesi percobaan?
28	Seberapa besar distraksi yang ditimbulkan oleh kualitas tampilan visual, yang dapat mengganggu atau mengalihkan perhatian Anda dari melakukan tugas yang diberikan atau aktivitas yang diperlukan?
29	Seberapa besar distraksi yang ditimbulkan oleh perangkat kontrol, yang dapat mengganggu atau mengalihkan perhatian Anda dari melakukan tugas yang diberikan atau aktivitas yang diperlukan?
30	Seberapa baik Anda dapat berkonsentrasi pada tugas yang diberikan atau aktivitas yang diperlukan dan bukan pada mekanisme yang digunakan untuk melakukan tugas atau aktivitas tersebut?
31	Apakah Anda mempelajari teknik baru yang dapat meningkatkan kinerja Anda dalam melakukan aktivitas di dunia virtual?
32	Apakah Anda terlibat dalam tugas eksperimental sampai-sampai Anda kehilangan jejak waktu?

We then recruit participant using a screener form which include their previous usage of VR devices. We then recruit the participant from undergraduate program of computer science, with 50% proportion from the first time VR user and experienced VR user. The participants then briefed about the purpose of the testing separately, use the VRFT, and then filled-in the presence questionnaire. Additionally, interviews were conducted to gather qualitative feedback and insights from the participants, allowing for a deeper understanding of their perceptions and experiences during the virtual tour.

3. Result and Discussion
3.1 Data Acquisition

The 360 scenes were captured in the village in West Java by researchers using Ricoh Theta V and monopod as part of a digital village ecosystem assessment conducted by the Software Engineering and Information Science Division in 2022. The 360 scenes are taken on several key locations of the village, with an example provided in Figure 2. Other information and content were also gathered in the field and through a literature search.

Fig. 2. Example of a 360-degree camera taken in the field. This image includes the internet of things kit used for automatic greenhouse regulation to support farmer's groups in the village

3.2 Design of Virtual Reality Field Trip

Table 2 presents the design framework for a VRFT aimed at introducing the concept of a digital village ecosystem. The table outlines different elements of the digital village ecosystem and their corresponding content within the proposed system. It also highlights the multimedia cone of abstraction [15] and the design elements of VR for education associated with each element [16]. The design elements include narration, video, virtual reality, text, and basic interaction with objects. The VR field trip focuses on providing panoramic 360 scenes, explainer videos, and visual explanations to address various aspects of the digital village ecosystem such as the demand and supply of digital services, economic sustainability, local ownership, and basic infrastructure. The immersive VR experience offers realistic surroundings, passive observation, and knowledge testing, fostering an engaging and interactive learning environment for users. Aside from the information in the table, users are also presented with a tutorial scene in which they can learn about basic navigation and interaction in the VRFT, which implements the instruction design element. Based on the design in Table 2 and information gathered in the field, we design the scene to be navigated by the learner.

Table 2
The design framework of the virtual reality field trip to introduce digital village ecosystem

Element of Digital Village Ecosystem [14]	Content of the Proposed System	Element of Multimedia Cone of Abstraction [15]	Design Element of VR for Education [16]
Demand for Digital Services	Panoramic 360 scene and explainer video	Narration, Video, Virtual Reality	Realistic surroundings, passive observation, knowledge test
Supply of Digital Services	Panoramic 360 scene, explainer video, and visual explanation of the devices	Narration, Text, Video, Virtual Reality	Realistic surroundings, passive observation, basic interaction with objects, knowledge test
Economic Sustainability	Explainer video and visual explanation of the devices	Narration, Text, Video	Realistic surroundings, passive observation, knowledge test
Local Ownership	Explainer video and visual explanation of the devices	Narration, Text, Video	Realistic surroundings, passive observation, knowledge test
Basic Infrastructure	Panoramic 360 scene, explainer video, and visual explanation of the infrastructure	Narration, Video, Virtual Reality	Realistic surroundings, passive observation, knowledge test

Table 3 provides a comprehensive overview of the scenes presented in the virtual reality (VR) field trip, their corresponding objectives, and the associated learning activities. The table highlights the key objectives of each scene, such as learning basic interactions, exploring outdoor plantations, understanding Horenso cultivation using IoT devices, gaining insights into digital service providers in the digital village ecosystem, examining IoT installations, and participating in a knowledge test. The learning activities within each scene involve navigating the virtual space, watching videos, examining visual information and images, interacting with IoT devices, and answering multiple-choice questions. This table showcases the diverse range of immersive experiences and educational opportunities offered by the VR field trip, enabling learners to engage actively with the digital village ecosystem and acquire knowledge through interactive and engaging activities.

Table 3
The list of scenes presented inside the virtual reality field trip, their objectives, and their learning activities

Scene	Objectives	Learning Activities
Tutorial	Learn the basic interaction used in the virtual reality field trip	Doing basic interaction to navigate and interact with object in the virtual reality
Outdoor Plantation	• Go to outdoor plantation and watch a short profile video of the farmer's group. • Examine the field activities photo documentations in gallery	• Navigating and watching the provided video in the virtual space • Choose and examine provided images from the actual field trip
Horenso (Spinacia oleracea) Greenhouse	• Go to horenso greenhouse and watch the video about horenso cultivation using IoT devices	• Navigating and watching the provided video in the virtual space
Tomato Greenhouse	• Learn about digital service providers involved in the digital village ecosystem	• Examine the visual information about all entities involved in the digital village ecosystem in the village
IoT Installation	• Go to IoT installation, examine the IoT devices, and learn on how it works	• Examine the IoT devices and interact with the information display to learn about how they work
Knowledge Test	• Provides answer to every question	• Answering a series of multiple-choice questions related to digital village ecosystem

3.3 Development of Virtual Reality Field Trip

In the development stage of our VRFT, we utilized Unity and Meta Quest 2 as the virtual reality headset to create an immersive learning experience. The proposed architecture, depicted in Figure 3, serves as the foundation for our VRFT system.

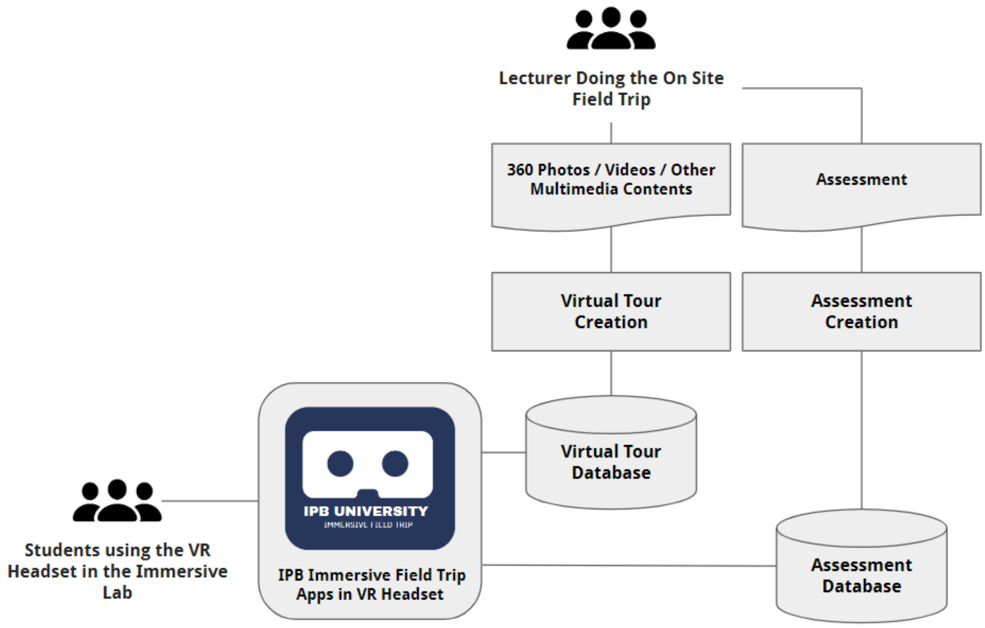
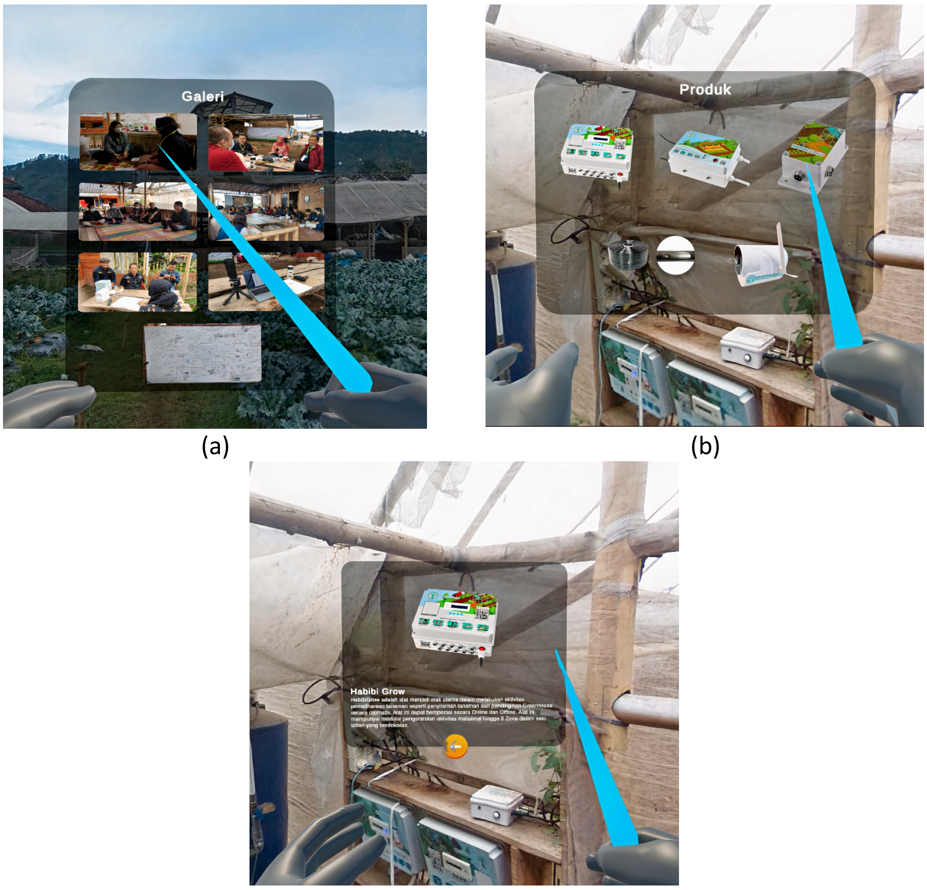


Fig. 3. Simplified architecture of the developed virtual reality field trip

The front-end system, which is installed on the VR headset, is accessible to learners in the immersive lab within the university. This front-end interface acts as the gateway for learners to engage with the VRFT content. Additionally, the front-end system is connected to an assessment database, which we implemented using Firebase. The integration of the assessment database allows for the seamless measurement of learning objectives within the field trip. Learners can access assessments directly within the VRFT, enabling the evaluation of their progress and understanding of the educational content. Moreover, the front-end system offers learners the option to select virtual tours. These virtual tours are pre-created by lecturers or other students who have previously undertaken the onsite field trip. By leveraging the front-end interface, learners have the opportunity to explore various virtual tours, each designed to facilitate experiential learning and provide an in-depth understanding of specific topics or locations. The availability of these virtual tours enhances the versatility and educational value of the VRFT system, enabling learners to choose from a diverse range of immersive experiences. Several key interactions provided inside the VRFT are presented in Figure 4.



(a) (b) (c)

Fig. 4. Several key interactions available in the virtual reality field trip, where user can interact with the data gathered in the field trip. (a) Examine the field activities photo documentations in gallery objective in outdoor plantation scene, (b) and (c): Go to IoT installation, examine the IoT devices, and learn on how it works in IoT installation scene

3.4 Evaluation

Based on the testing and evaluation with 22 participant (Figure 5), Table 4 presents the score of presence components for the overall group of participants (n = 22) and further separates the ratings for first-time VR users (n = 11) and experienced VR users (n = 11). The Control Factor shows slightly higher ratings for first-time VR users (5.62) compared to experienced VR users (5.34), with an overall average rating of 5.52. The Distraction Factor has similar ratings between the two groups, with the overall average rating at 5.20. In terms of the Sensory Factor, first-time VR users rated it slightly higher (6.04) compared to experienced VR users (5.57), resulting in an overall average rating of 5.80. The Realism Factor also showed slightly higher ratings for first-time VR users (5.85) compared to experienced VR users (5.47), with an overall average rating of 5.66. Finally, the Involvement component had an average rating of 4.96 for the overall group, with first-time VR users rating it slightly higher (5.27) compared to experienced VR users (4.64).

Fig. 5. Testing and evaluation condition, where participant use the virtual reality field trip, filled-in the presence questionnaire, and interviewed

Table 4
The statistical summary of the presence questionnaire administered in the evaluation; scale is from 1 to 7

Presence Component	Overall (*n* = 22)		First Time VR User (*n* = 11)		Experienced VR User (*n* = 11)	
	Average	STDEV	Average	STDEV	Average	STDEV
Control Factor	5.52	1.33	5.62	1.37	5.34	1.39
Distraction Factor	5.20	1.61	5.36	1.65	5.03	1.56
Sensory Factor	5.80	1.20	6.04	1.12	5.57	1.24
Realism Factor	5.66	1.34	5.85	1.37	5.47	1.28
Involvement	4.96	1.71	5.27	1.64	4.64	1.76
Total	5.43	1.41	5.63	1.37	5.21	1.39

STDEV = Standard deviation

The overall total score, was 5.43 with first-time VR users having a slightly higher rating (5.63) compared to experienced VR users (5.21). These findings suggest that both first-time VR users and experienced VR users perceived a moderate level of presence in the virtual environment. Among the presence components, the involvement factor received the lowest average score of 4.96, with a relatively high standard deviation of 1.71. This suggests that participants' level of engagement and immersion varied significantly during the VR field trip application. The relatively lower score indicates the need for further investigation and potential improvements in designing more captivating and immersive VR experiences to enhance users' involvement. As stated in [24], although virtual reality enabling complex interaction and learning experience, there is a barrier of cost and development to create more complex simulation and experience inside the tour. Nevertheless, with the recent development of more intuitive and sustainable virtual reality authoring tools [25,26], complex interaction and simulation can be achievable in the near future with lower cost and resources.

The other presence components had relatively higher average scores. The control factor received an average score of 5.52, indicating a moderate level of perceived control within the VR environment. The distraction factor had an average score of 5.20, suggesting that participants experienced some level of distraction during the virtual field trip. The sensory factor received an average score of 5.80, indicating a good level of sensory immersion while the realism factor received an average score of 5.66, suggesting a moderate perception of realism within the VR field trip application. Overall, the total presence score was 5.43, reflecting a moderate level of presence experienced by participants during the VR field trip application.

The lower score in involvement indicates the needs to increase the interaction presented in the field trip. Based on the interview, participants already feel engaged in activities in the virtual environment due to their curiosity to explore. The necessity to complete objectives also affects the users' sense of engagement. Some participants lose track of time because they are interested in exploring and become unaware of the passing time. However, there are also those who feel bored with the application content and become aware of the time that has passed while using it. Some user opinions include "*because VR is a new medium, it makes me curious, but the content is limited to knowledge only*" and "*because the videos are boring, it feels like it takes a long time.*"

Meanwhile, participants already tend to be less aware of their surroundings when using VR for learning simulations, although some participant users remain aware of their environment and the devices, they are using due to external sounds and the weight of the VR headset and control button in their hand controller. The control mechanism on the Hand VR is considered disruptive for new participant users as it can be confusing at times. The visual display quality also receives mixed opinions from participant users but does not significantly affect concentration in completing objectives, unlike visual disturbances caused by ill-fitting VR headsets for glasses-wearing participant users. Direct quotes from participant users include "*the VR headset is uncomfortable, so it's blurry, and the subtitles are blurred*" and "*once in the play area, I couldn't see or hear my surroundings.*"

The interviews identified areas for improvement, such as enhancing content quality and increasing natural interaction within the system. In conclusion, this research has laid the foundation for the IPB Immersive Field Trip Platform by developing a virtual field trip that introduces computer science students to a digital village ecosystem.

4. Conclusion

In conclusion, this research has successfully developed a virtual reality field trip to introduce a digital village ecosystem to computer science students with consideration of multimedia cone of abstraction and design element of virtual reality for education. The testing and evaluation of the application with 22 participants revealed a moderate level of presence experienced by both first-time VR users and experienced VR users. The presence components, including Control, Distraction, Sensory, Realism, and Involvement factors, were assessed and showed variations between the two groups. The involvement factor received the lowest average score, indicating the need for further investigation and improvements in designing more engaging and immersive VR experiences. Participants' level of engagement and immersion varied significantly during the VR field trip, suggesting the necessity to increase interaction and make the content more captivating.

The control factor was rated moderately, indicating a satisfactory level of perceived control within the VR environment. The distraction factor revealed that participants experienced some level of distraction during the virtual field trip, but it did not significantly affect their ability to complete objectives. The sensory factor received a good score, indicating a satisfactory level of sensory immersion. Participants perceived a moderate level of realism within the VR field trip application, as reflected by the average score in the realism factor. Overall, the total presence score indicated a moderate level of presence experienced by participants during the VR field trip, however, the findings highlight the need to address the weaknesses identified in the involvement component. The findings demonstrate promising results and provide insights for further refinement of the platform.

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