Evaluating Low Embodiment Multi-User Virtual Reality Learning Environments in Remote Art Education

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Abstract. The COVID-19 lockdown forced education to make a shift to Emergency Remote Learning (ERL) model, raising multiple issues, such as the higher level of distraction, absence, and scheduling difficulty. To improve the level of student engagement, a low condiment Multi-User Virtual Reality Learning Environment (MUVRLE) with high accessibility was built and assessed to evaluate its usability and effectiveness. A low embodiment MUVRLE was used for maximal accessibility and was compared with the traditional remote learning environment. 100 college students were invited to the experiment. A MUVRLE system based on Mozilla Hubs was designed to create a multi-user virtual classroom based on a course of 19th art history. Students participated in 2 questionnaire studies after they finished the experiment. The evaluation of System Usability Scale (SUS) was conducted in comparing the actual system usability of the MUVRLE model and traditional remote model. The outcome suggested that low embodiment MUVRLE learners had a better performance. Additionally, the low embodiment MUVRLE model had better usability than traditional remote learning in art education.

Keywords: Remote learning, art learning, multi-user virtual reality learning environment, system usability scale.

1. Introduction

The major lockdown in the COVID-19 pandemic has caused a series of challenges to education, bringing the problems of the Emergency Remote Learning (ERL) model. In this model, students are required to attend in a fixed environment from their homes. They often feel distracted, less focused, and find it hard to arrange their schedules, resulting in a higher rate of absence. [1] On the other hand, VR (Virtual Reality), as a new framework of learning, has become an option in attracting the awareness of students. Various research suggested that the model of Virtual Reality-based immersive learning can improve the sense of immersion and engagement of learners [2-3].

In this paper, a low embodiment MUVRLE experiment, namely low-cost MUVRLE environments created on general-purpose devices, such as PC, giving users a lower sense of embodiment, was conducted based on the topic of Vincent Van Gogh and 19th-century art history. The open-sourced MUVRLE platform Mozilla Hubs was used in designing a test environment compatible with all kinds of devices for maximal accessibility and were compared with the traditional remote learning environment. In this environment, users can take remote art history classes on their personal computers, immersed in a real-time interactive virtual space.

To evaluate the performance and system usability of a MUVRLE with a low factor of embodiment, both an objective questionnaire assessment and a SUS evaluation was conducted based on the platform of PC and smartphone. The result showed that the low embodiment MUVRLE model outperformed traditional remote learning in system usability. ($p<0.01$) Additionally, MUVRLE learners had a better learning performance.

2. Related Work

Virtual Reality (VR), has a lot of potential in teaching science, language, history, and art [4]. Burdea and Coiffet proposed the III theoretical framework of Virtual Reality: Immersion, Interaction, and Imagination. They proposed that: VR provides an immersive human-computer interaction model, allowing the brain to better imagine unreal objects and scenes, further improving their cognition [5].

Therefore, this HCI model provides an overall stronger sense of engagement compared to the traditional methods.

Dengel et al. proposed the Educational Framework of immersive Learning (EFiL) in which the sense of presence was recognized to be a main factor which largely affects immersive learning. Furthermore, the sense is affected by the objective (immersion), and subjective factors: motivation, cognition, and emotion [6-7].

On the other hand, the accessibility of Virtual Reality experience is crucial in conducting such teaching programs. The research conducted by Tavarez et al. shows: post-pandemic remote education should pay more attention to improving participation, the main lacking factor in remote teaching, as well as concern the accessibility due to the different levels of information accessibilities, with the remarkable increase in terms of the absence rate of a student [8].

However, it is possible to conduct a program on a general-purpose platform with higher accessibility, namely personal computer, and smartphone. Mina proposed that video games high accessibility platforms such as PC and smartphones can both be powerful means of science education. The head-mounted VR platform did not have major advantages over the 2D PC groups despite its predicted higher performance due to its higher embodiment of experience [6]. According to the much higher accessibility of 2D PC and smartphone platforms despite their low, it is more universal to conduct on certain types of low embodiment platforms.

Muti-User Virtual Reality Learning Environment (MUVRLE) allows for multiple users to learn synchronously in the same VR environment. The main advantages of MUVRLE include a strong immersion for teachers and students, and the sense of physical presence and support originated from collaborative socialization. Virtual classrooms can be created based on this technology [7]. The technology is used in multiple areas of interest, for example, medical collaboration education [8], Chinese education [9], mining education [10]. Among all the methods, Mozilla Hubs, being an open-sourced MUVRLE platform, is compatible with a wide range of devices, ranging from professional head-mounted displays to normal 2d personal computers & smartphones. This MUVRLE platform was already used in education studies, on the topic of Chinese learning. Samuel et al. [9] conducted a qualitative research study that suggests that: this tool is high in interactivity and is considered easy to use at the same time. Multi-User Virtual Reality Environment (MUVE) other than Mozilla Hubs, namely VRChats, exclusively works on Microsoft Windows operating system [11]. The MUVE also requires the user to install Steam software. [12] The higher technical demand raises the standard of users' access to information. Therefore, Mozilla Hubs is better fitted for the context of remote learning.

In the professional field of art education, VR has already been implemented. The Carroll County Public Library, located in Maryland, US, showed VR demos in a high school, providing a similar experience in another art course. [10] Regina et al. used Unity in the project VR-iedrich to create a virtual 3D world, conducting education in a 360 degree-view. The method allowed for a new method of art education context, including showing the comprehensive historic knowledge about artists, artworks, in their historical context, to reimagining those scenes in a new, immersive way [13]. Such a series of education shares the feature of the high embodiment, namely VR-Head-Mounted-Display-based multi-dimensional interaction, which requires a series of devices to conduct education.

On the other hand, Mozilla Hubs as a MUVRLE platform was also used in a movie production course, in the field of remote art learning [14-15]. Most art education departments, similar to other professions, use traditional remote learning methods. It is a practical method of conducting research in the field of MUVRLE learning.

3. Methods

In this study, the low embodiment MUVRLE environment was created. It was designed in Mozilla Hubs Spoke, a web-based 3d scene editor which allows for the customization of the MUVRLE room. 3d models, as well as related videos, were put into the room. The users would be allowed to join the

room by entering the link in a web browser. The scene was compatible with 2d PC and smartphones. Thus, the 2 experiment environments had the same level of accessibility. The scene was designed and modeled according to a topic: Vincent Van Gogh and 19th-century European art history and was presented for comprehensive evaluation of effectiveness and system usability. The new low embodiment MUVRLE environment aims to solve the problem of low interactivity of remote learning environments while having much better accessibility for most learners.

The student's learning performance and system usability were to be evaluated. The effectiveness of the environment, consequently, could be improved based on the analysis. In the study, the research methods used included:

- Objective questionnaire evaluation: Each learner gets an objective questionnaire with 5 questions about Vincent Van Gogh after they finish the lesson. (100 pieces, 50 traditional remote learners and 50 MUVRLE learners). The correct rate of each individual was thus evaluated. The highest score for each objective questionnaire was 5, and the lowest was 0, based on whether the participant was correct or not.
- SUS evaluation: A standardized value of system usability value evaluation program was conducted to assess the usability metrics of the remote learning field and low embodiment MUVRLE model, and to make a comparison of the differences in terms of the usability metrics of the system between the two fields. A SUS assessment of a certain type was conducted each time after individuals finished their experience in the environment. The questionnaires used in this experiment contained 10 questions, scored with a 5-point scale. The Q1, Q3, Q5, Q7, Q9 had a positive meaning, while the other questions were negative. [16, 17] All data obtained from this study was put into SPSS for analysis.

3.1. Experiment Participants

In total, 100 individuals participated in this study, 62 males and 38 females. The participants were all undergraduate college without knowledge of the learning topic. The experiment was conducted in 2 groups of the same size: 50 remote learners in the control group and 50 MUVRLE learners in the experiment group. After they finish their first experiment, the 2 groups switched sides, taking another experiment and receiving a SUS evaluation questionnaire afterward. They did not take the objective questionnaire evaluation again.

3.2. Field Stimulus and Assessment Methods

The field stimulus implemented was the different MUVRLE environment and remote learning environment. Since the participants were all Chinese students, DingTalk, being their daily-used remote learning tool, was used in the traditional remote learning group as the control group. For the experiment group, Mozilla Hubs was used in the MUVRLE (Figure 1) environment. The two groups had the same learning goal, which was to learn the basics of Van Gogh and 19th-century art history. After each group finished their course for the first time, they took an objective questionnaire assessment, shown in Table 1, to analyze their learning performance. In addition, both control and experiment groups were required to participate in completing a table designed for usability test, as was presented in Table 2.

Figure 1. Low Embodiment MUVRLE for Art Learning

Table 1. Objective Questionnaire of van Gogh and 19-th Century Art History

Item	Option (Choose One)			
	A	B	C	D
Q1: Vincent Van Gogh is recognized as an artist of _. A. Modernism B. Impressionism C. Post-Impressionism D. Neo-Impressionism	○	○	○	○
Q2: Vincent Van Gogh is known for improving the expression of _ & _. A. color, light B. nature, reality C. color, atmosphere D. line, color	○	○	○	○
Q3: In terms of art style, Van Gogh is more similar to _. A. Edouard Manet B. Pierre Auguste Renoir C. Paul Gauguin D. Francisco Goya	○	○	○	○
Q4: Van Gogh is an artist of which century? A. 1600-1700 B. 1700-1800 C. 1800-1900 D. 1900-2000	○	○	○	○
Q5: Which following piece of art is NOT done by Van Gogh? A. Bedroom in Arles B. The Night Café C. The Basket of Apples D. The Starry Night	○	○	○	○

Table 2. Subjective Questionnaire of the SUS Assessment

Item	Disagree			Agree	
	1	2	3	4	5
Q1: The participant was positive towards frequently using the art learning environment of _	○	○	○	○	○
Q2: The participant found _ art learning system too complex to use	○	○	○	○	○
Q3: The participant perceived a high level of ease of use	○	○	○	○	○
Q4: The participant needs technical support	○	○	○	○	○
Q5: The participant perceived a high level of functionality integration	○	○	○	○	○
Q6: The participant believed that the system was inconsistent in terms of functionality	○	○	○	○	○
Q7: The participant believed that the majority of people could easily learn to use certain environment	○	○	○	○	○
Q8: The participant believed that the system was generally clumsy to use	○	○	○	○	○
Q9: The participant had confidence in using the system	○	○	○	○	○
Q10: The participant needed preemptive learnings to get to use the system	○	○	○	○	○

4. Performance Evaluation

After finishing collecting the objective questionnaire from participants, participants were graded based on the correctness of the quizzes shown in the questionnaire. The statistics of grades are shown below in Table 3. Generally, participants from the low embodiment MUVRLE group (Mean=2.04) performed better than the remote learning group (1.92).

Table 3. Statistics of objective questionnaire scoring

Group	N	Mean	SD
Remote Learning Environment	50	1.92	0.966
Low Embodiment MUVRLE Model	50	2.04	0.989

4.1. SUS Score Evaluation: Remote Art Learning

The overall SUS analysis was conducted based on the experiment data of students' questionnaire feedback, as is shown in Table 4. According to the rule of SUS analysis, the SUS score was computed in the following equation with the mean value of each item.

According to the computing, the study suggested that the final SUS score for remote art learning is: 52.48 by summing up the mean value and calculating. According to Brook et al., the score was in the range of F (0-59), which was between the level of OK and Good. The acceptability range was low marginal.

Table 4. Statistics of SUS Analysis Items, remote art learning environment

Item	*N*	Mean	SD
Q1: The participant was positive towards frequently using the art learning environment of remote education	100	3.02	1.128
Q2: The participant found remote art learning system too complex to use	100	3.23	1.090
Q3: The participant perceived a high level of ease of use	100	3.17	1.045
Q4: The participant needs technical support	100	2.82	1.114
Q5: The participant perceived a high level of functionality integration	100	3.06	1.062
Q6: The participant believed that the system was inconsistent in terms of functionality	100	3.07	1.085
Q7: The participant believed that the majority of people could easily learn to use remote art learning environment	100	3.23	1.014
Q8: The participant believed that the system was generally clumsy to use	100	2.84	1.070
Q9: The participant had confidence in using the system	100	3.43	1.037
Q10: The participant needed preemptive learnings to get to use the system	100	2.96	0.619

4.2. SUS Score Evaluation: Low Embodiment MUVRLE

The SUS assessment of low embodiment MUVRLE art learning environment was shown in Table 5. According to the data, it could be observed that users significantly prefer to use the MUVRLE frequently compared with remote art learning, which was the major factor contributing to the difference in SUS computing. Additionally, users felt that the low embodiment MUVRLE was also easier to use. On the other hand, the learners did not perceive much difference in the level of function integration, and the perceived level of usefulness, in terms of Q5, Q6, Q7, Q8.

According to the rule of SUS analysis [18], it was necessary that the odd-numbered questions get reduced by 1 point each in the final evaluation. The even-numbered questions, on the other hand, receives -5 each to signify the negative feedback. After all the data analysis, the sum of the mean values was required to be multiplied by 2.5 to achieve the standard score for analysis. The final SUS result was 57.83, which was also in the range of F (0-59), locating between the range of OK and Good. The acceptability range, same with remote art learning environment was low marginal.

4.3. SUS Score Evaluation: Remote Art Learning

The SUS scores of remote and low-embodiment MUVRLE art learning are: 52.48 and 57.83. It could be observed that the model of MUVRLE group significantly outperformed the traditional remote learning model in the field of art education ($p<0.01$). The results indicated that more people were significantly more willing to use the MUVRLE in art learning frequently than taking remote classes. Additionally, participants perceived a higher ease of use in the low embodiment MUVRLE environment.

Table 5. Statistics of SUS Analysis Items, remote art learning environment

Item	N	Mean	SD
Q1: The participant was positive towards frequently using the art learning environment of remote education	100	3.02	1.128
Q2: The participant found remote art learning system too complex to use	100	3.23	1.090
Q3: The participant perceived a high level of ease of use	100	3.17	1.045
Q4: The participant needs technical support	100	2.82	1.114
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5. Conclusion

This paper evaluated low embodiment Multi-User Virtual Reality Learning Environment (MUVRLE) in art learning, with the goal of improving the sense of engagement in the remote learning environment to help learners better focus on the topic while having the same level of accessibility. A MUVRLE room was created on the platform of Mozilla Hubs and was experimented based on a course on Van Gogh and 19th-century art history. 100 participants took part in the experiment and were assessed in the field of general performance and perceived usability of the system. The experiment results showed that the low embodiment MUVRLE model (Mean Correct Rate: 2.04, SUS score: 57.83) generally provided better learning performance and higher system usability than the traditional remote learning environment (Mean Correct Rate: 1.92, SUS score: 52.38). Thus, the evaluation suggested that the low embodiment MUVRLE model can be both beneficial and easy to use for remote art teaching compared with traditional art teaching.

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