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Research Article

VR-Assisted Environmental Education for Undergraduates

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Environmental education is an important approach to improve students' environmental literacy. The method of environmental education in colleges and universities is advancing with the development of multimedia technologies, among which virtual reality (VR) technology is gradually being widely applied to education due to its strong sense of immersion and interactivity. This article focuses on the application of VR technology to environmental education in colleges and universities, using EduVenture APP and VR glasses to innovate environmental education, with the aim of improving students' performance and making a strong connection between sense and activity of environmental protection. This research found that the learning efficiency and the sense of environmental protection of students were enhanced with VR assistance in comparison to traditional instruction, and students' learning interest in environmental protection activity was also improved.

1. Introduction

Environmental education is a process that allows individuals to explore environmental issues, engage in problem-solving, and take action to improve the environment [1]. As a result, students develop a deep understanding of environmental issues and have the skills to take responsible actions. It is the study of the relationships and interactions between natural and human systems. Environmental education is provided so that people can better understand the world around them and know how to take care of it properly so that the world can be a better place.

Strengthening environmental education is conducive to the formation of correct development values for students and promotes the comprehensive growth of students, as well as the sustainable development of society. The content of environmental education includes awareness, knowledge and understanding, attitudes, and participation [2]. In recent years, environmental education in China's colleges and universities has gained some achievements, and many talents have been developed with both virtue and the ability to protect the environment. Since the 1970s, the method of environmental education in colleges and universities has been evolving [3].

Currently, there are problems in environmental education in colleges and universities: one is emphasizing knowledge learning and neglecting practice, so there is a gap between "knowing" and "doing." Environmental education in colleges and universities can be realized by integrating it with geography courses and social practice. Students can have a deeper understanding of environmental protection when integrated into practice [4]. Only theoretical education makes it more difficult for students to deeply appreciate the meaning and role of theory. Practical teaching on environmental education is susceptible to restrictions in time and space, safety, and funding, so VR glasses are now a safe and economical substitute [5]. The other problem is that students lack interest. Many students consider environmental education boring because most teachers teach through lecturing and the number of students in the classroom is generally large. Students in colleges and universities are growing up in the rapidly developing Internet era, so the Internet and VR technology can more easily draw students' interest [6].

With the cost of VR equipment reducing rapidly and the increasing quality of virtual experiences, VR has become more and more popular in education since the 2010s. Learners can explore autonomously in a way close to nature

in environmental education. Due to its strong immersion and interactivity feature, VR is a new tool to promote the deep integration of knowledge and practice in environmental education and increase the interest of students [7].

In summary, VR technology is applied in the environmental education of colleges and universities to improve environmental education [8, 9]. First, it is a new means of teaching and is a useful exploration, which innovates the teaching mode of the environment. Immersive experiences change the single way of teaching that teachers teach, and students passively accept, using their interactivity to enhance communication between students and what they have learned. Second, applying VR to environmental education can better represent content scenarios. Students understand complex concepts through various forms of presentation to create new experiences. Third, use VR technology to innovate the practice of environmental education in colleges and universities. Students can use VR equipment under the guidance of teachers to enter virtual practice scenes for practical experience activities. At the same time, it can break the limitations of time and space and improve learning efficiency.

This article took college students as an example to explore the effectiveness of VR-supported environment education and to assess whether VR technology can improve student' interest and tighten the connection between knowledge learning and practice.

2. State of the Art

Around the world, environmental education has a very important position and function. Environmental education in China is a selective course in college. According to their own cultural background and actual needs, countries around the world have adopted different educational means in environmental education. With the progress of science and technology and the development of the Internet, researchers have begun to explore the application of new technologies in the field of environmental education, of which VR technology is one of the important attempts.

VR technology was first used in the aerospace, medical, and military fields and began to be used in the education industry in the 1990s. In 2016, the combination of VR and education ushered in a major development, and many excellent application cases emerged.

In combination of VR and education, the first application is in medical education, STEM education, and other fields. Shim et al. [10] explored the role of VR technology in the teaching of biology. The authors use VR technology to simulate the structure and function of the eye, and by the visual presentation of the iris and pupil, students can more intuitively understand the changes that occur after changing the viewpoint. The impact of VR technology as a means of communication on the teaching of history was expounded. Studies showed that VR technology has an advantage in simulating events in history and restoring three-dimensional sensory virtual worlds [11]. King et al. [12] designed a VR application that simulates clinical medical practice from the perspective of practical technical training. Enable students to become doctors on the app and experience the medical process from the first perspective. This simulated experience has the advantage of allowing students to trial and error in a virtual environment, thereby reducing real-world mistakes. It is beneficial to improve the clinical experience and self-confidence of medical students and clarify the possibilities and advantages of VR technology for practical discipline education.

In terms of student learning interests and abilities, Hutchison [13] explored how VR technology can be used experimentally to improve students' discovery and learning ability. This experiment allowed students to learn independently through VR devices and find answers in the virtual world, exploring the possibilities of VR technology to improve students' self-learning ability. Gutiérrez et al. [14] argued that the application of VR technology to education can motivate students to learn independently. The role of VR technology in creative education was explored. The experimental results showed that VR technology is conducive to cultivating the ability of students to innovate and create [15].

In terms of learning effectiveness, the impact of VR technology on learning outcomes was explored. The study imparts the same learning content to students through VR technology and traditional classroom presentations. The results show that VR technology can better disseminate knowledge due to its advantages of information integration, reducing the process of students transcoding information [16]. The positive impact on the perception of student learning and emotional perception in the education process was also experimentally confirmed [17].

In terms of the combination of VR and environmental education, relevant research has also been gradually carried out since 2011. The construction of the VR-supported education teaching model was discussed in environmental education, and the shortcomings were reflected. Wan [18] took the Jinggangshan Troop Confluence VR project as an example to try to integrate VR technology into the teaching of value courses. Ding and Yao [19] took the Siming Mount Revolutionary Martyrs Monument project as an example, summarized the experience of the design, development, and application of the project, and innovated a new form of VR and integration of environmental education. Wu et al. [20] proposed the theory of learning space expansion. From the perspective of expanding the learning space, it was proposed that VR technology can be used to create a specific learning space for teaching activities, and activity theory can be used to design teaching activities.

During COVID-19, the VR classroom showed potential for remote learning, and students were highly motivated and perceived the VR classroom as fun to use. The author noted that VR is at the tipping point of becoming a regular part of school programs [21]. Research also showed the effectiveness of the integration of VR practices for medical students [22, 23]. Shu and Huang innovated a teaching model to integrate STEM education and VR, showing that VR content is a more effective teaching method than PowerPoint slides and improved student' Maker self-efficacy [24]. However, there is little research on environmental education during and after the COVID-19 pandemic.

In summary, current research on VR-assisted education mainly focuses on three aspects: in the field of discipline education, in terms of students' learning interests and abilities, and the impact on learning effectiveness. These studies have shown that the application of VR technology to education can enhance students' interest in learning and learning ability and improve the effectiveness and depth of learning. Therefore, there is great potential for applying VR technology to environmental education. There is relatively little research on the application of VR technology in environmental education in colleges and universities; most of the research on the application of VR technology to education has been adopted to medical training and STEM learning and to prove the effectiveness and potential of VR technology as a means of communication.

3. Research Methodology

This article takes environmental education as an example, combined with the EduVenture VR app, and systematically excavates students' consciousness and actions in an immersive environment. It is expected that in the integration of VR technology and environmental education in colleges and universities, we will explore a more abundant curriculum that integrates theory and practice to improve the educational effect and student satisfaction.

In this research, the EduVenture app and Shinecon glasses together make learning media. The EduVenture app was developed by the Center for Learning Science and Technologies of the Chinese University of Hongkong for education [25]. It provides rich VR learning resources for many courses, such as arts, language learning, math, P.E., science, culture, and environment. For the environmental course, various scenes are provided, from rain forest to volcano park and from river to mountain. It is allowed to interact with the content by answering questions or recording answers and submitting them. Compared with Google Cardboard, we chose Shinecon glasses because it is easy to use, like cardboard, but more convenient to wear, as well as cheap in price, about 15 $. This app and glasses enable feasible resources and an economical way for the design of a new approach to environmental education. The VR-assisted left classroom is shown in Figure 1.

Four fields of environmental education content were chosen to compose topics to learn: ocean, river, and left air pollution; plants and forests; animals; city and living environment. In the virtual world built with VR technology, students are placed in a virtual scene from the first perspective, and they can immerse themselves in the virtual environment. Also, in the virtual environment, students can interact with things. These interaction methods are multiangle and three-dimensional, and students can get responses immediately. Figure 2 shows one scenario of the learning process, and multiple choices are provided for students to interact with the learning content.

Instruction was designed in a blended curriculum, and the course book Introduction to Environment Protection was selected [26] as the learning material. The knowledge part of environmental education was conducted online before the class, and the deep experience and practice part was conducted through VR glasses in the classroom. Eight 3D learning videos were selected from the EduVenture app according to the course book. Blended instruction that integrates with VR glasses was implied in the experimental class conducted for 2 months, while the control class still used traditional classroom teaching. In this article, quantitative methods are used to conduct an empirical study on the learning effect and perception of college students on environmental education.

Figure 1: The VR classroom.

One hundred students from the first and second years of a university in Chongqing were selected. The students were randomly placed into two groups. 50 students in the control group and the other 50 students in the experimental group. There were 29 males and 21 females in the control group with an average age of 19.32 years and 28 males and 22 females in the experimental group with an average age of 19.21 years. The control class adopts traditional classroom environmental education, and the experimental class adopts the new instruction supported by VR.

The teacher sent consent forms to the students. The study began with the administration of two pretests after the consent forms were returned. After the posttest, data analysis was conducted through a comparison of environmental protection conscious level tests before and after the teaching procedure, and the questionnaire was also analyzed.

The questionnaire was self-designed based on the sense of acquisition scale by consulting with professors. It was composed of the first demographic information and Likert scale. Making the questionnaire scientific is the key to ensuring the reliability of the survey results. First, the survey in this study uses a self-compiled questionnaire based on references to the relevant questionnaires. There is no authoritative questionnaire that can be directly used in the research, so the existing literature is sorted out, a hypothetical model is established, the dimension of college students' sense of environmental protection is divided, and the evaluation index system of sense of fulfillment of college students from environmental education is constructed. Second, through interviews between experts and students, extensive listening to the suggestions of professional teachers, and combined with theoretical research, the measurement scales were constructed and used SPSS 26 for

Figure 2: A scenario of a rainforest from VR glasses.

reliability and validity testing. The learning effect of college students' environmental education courses is divided into three factors: knowledge acquisition, emotional acquisition, and action acquisition. The main structure of the questionnaire has two parts: the first part is demographic information and the second part is the sense of the acquisition of knowledge, emotions, and actions by students in environmental education courses.

The pretest, posttest, and questionnaire test results were analyzed by using the SPSS (Version 26) software package (SPSS is the abbreviation of Statistical Package for the Social Sciences, which is a powerful statistical software platform of IBM). SPSS was used to conduct internal consistency analysis and correlation analysis of the data obtained by using the questionnaire from the pioneer survey, to verify the reliability and validity of the questionnaire, and to eliminate substandard questions in the questionnaire. Second, SPSS 26 was then used to transform and integrate the data, perform descriptive analysis and difference analysis, and summarize and compare the differences in environmental education courses of college students in effect and sense of acquisition.

4. Data Collection and Analysis

4.1. Reliability Analysis. Reliability refers to the stability and consistency of the results measured by the test or scale tool. The greater the reliability of the scale, the smaller the standard. The commonly used method of testing reliability is Cronbach's alpha coefficient created by L.J. Cronbach in 1951, most used in the Richter scale, which represents the internal consistency reliability of the scale by α coefficient values, and the higher the α coefficient, the better the internal consistency of the scale. At present, the publicly accepted standard in the academic community is as follows: If the α coefficient is between 0.60 and 0.65, it is best not to keep; α coefficient value bounded between 0.65 and 0.70 is the minimum acceptable value; α coefficients are quite good between 0.70 and 0.80; the coefficient values are very good between 0.80 and 0.90. The internal consistency coefficient (Cronbach's alpha) of the environmental class acquisition scale of college students compiled in this study is 0.926, greater than 0.90, and the values of the internal consistency coefficient of the three dimensions are 0.833, 0.909, and 0.926, greater than 0.80. The data in Table 1 show that the total number of college students' sense of the environmental protection acquisition table and the reliability indicators of each dimension are ideal. The information on the scale is stable, and the reliability of the questionnaire is very good. The internal consistency coefficients of each dimension are given in Table 1.

Table 1: Reliability coefficients of each dimension in the sense of the acquisition scale of environmental protection.

Cronbach's alpha (α)		Number of items	Remarks
Knowledge acquisition	0.833	14	Pass the test
Emotional acquisition	0.909	8	Pass the test
Action acquisition	0.926	8	Pass the test

4.2. Analysis of the Results of the Pre and Posttest of College Students' Environmental Protection Level. On the basis of the results of SPSS, we can see that there is a slight difference between these two groups. The average scores for the two classes were 73.05 in the experimental class and 74.68 in the control class. The independent sample t-test showed that the difference between the experimental class and the control class was not significant ($p = 0.891 > 0.05$), which means that the two classes were similar in knowledge level before the experiment. To prove the authenticity of the experiment, the class with a lower average score was chosen as the experimental class, which was 1.63 points lower than the control class (Table 2).

After the experiment, the posttest scores were analyzed. In the posttest, the mean scores of the experimental class and the control class were 80.48 and 76.10, respectively, as shown

Table 2: Pretest results and comparison.

Group statistics					
	Group	N	Mean	Std. deviation	Std. error mean
Pretest	Experimental	50	73.0500	10.01682	1.41659
	Control	50	74.6800	10.36495	1.46583

Independent samples test										
		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Pretest	Equal variances assumed	0.046	0.831	−0.137	98	0.891	−0.2800	2.03847	−4.32529	3.76529
	Equal variances not assumed			−0.137	97.886	0.891	−0.2800	2.03847	−4.32535	3.76535

in the table. With the independent sample t-test, the equality of the means of the posttest was $p = 0.034 < 0.05$; it is to say that there is a significant difference between the two classes in the performance of the posttest. The average score of the experimental class was significantly higher than that of the control class (Table 3).

At the same time, we also compared the results of the experimental class before and after the experiment, and the results are shown in Table 4. According to SPSS analysis, the t-test showed $p = 0.003 < 0.05$, and the difference between the pretest and the posttest in the experimental group was significant.

In the pretest, we compared the scores of the two classes horizontally, and the level of knowledge of the students was not significant, while in the posttest, we compared the scores after the test. The mean score of the experimental class increased from 73.05 to 80.48, and at the same time, the mean score of the control class increased from 74.68 to 76.1.

From the contrast of the scores of the two exams between the two classes, we can know that in the experimental class, the average scores of the posttest exam of the subjects have increased by 7.43 points compared with that of the pretest. In the control class, the average posttest score of the subjects increased by just 1.42 points compared with the pretest. The positive results demonstrated the obvious improvement the students have made in the experimental class. Although the levels of the subjects have improved in both classes, we can see that the subjects in the experimental class have improved more significantly. It showed that most of the students made progress from their original levels and VR-assisted blended instruction was effective in improving the student's exam performance in environmental education.

4.3. Analysis of the Results of the Questionnaire Survey. At the end of the teaching experiment, the questionnaire was distributed to the students in the experimental class. The questionnaire survey is in the form of a secret name, which is uniformly distributed by the teacher in the classroom in the hands of the students, and before the students fill in the questionnaire, the author explains the precautions to the students and personally supervises the completion to ensure that the students answer carefully. According to the number of respondents, a total of 50 paper questionnaires were distributed, 50 were recovered, 49 valid questionnaires were recovered, and the effective rate of the questionnaires was 98%.

Now, the questionnaire is divided into three parts: sense of knowledge acquisition, sense of thought acquisition, and sense of behavior acquisition, and the results are as follows:

Through the survey of the current situation of the sense of acquisition of the environmental education class of college students in Table 5, current college students have gained basic theoretical knowledge of environmental protection and form a sense of knowledge acquisition. According to the survey results, we can see that college students' sense of knowledge acquisition is relatively strong; in the question, through the study of the environment, what knowledge do you think you have learned? 88.37% of the students believe that they have learned the core values of environmental protection knowledge; 83.24% of the students believe that they have learned the basics of environment protection and the analysis of environmental phenomena and problems; 78.89% of the students believe that the environmental education course has taught them the relevant knowledge of the environment and deepened their understanding of the world we live. This not only showed that college students have a strong sense of knowledge through the VR-assisted course but also showed that the measures taken by colleges and universities in environmental education have achieved great results, but there is still room for progress, so we also need to further explore the methods and paths to enhance the sense of acquisition of college students in environmental education.

According to the survey data in Table 6, we can find that most students have gained emotional acquisition after the course, including emotional identity, value belief, will quality, and other aspects of the sense of acquisition. In the question, through the study of an environmental education class, what is the guiding effect on your thinking? Among the choices, 86.2% of the students believe that they have

Table 3: Results of the posttest and comparison.

Group statistics					
	Group	N	Mean	Std. deviation	Std. error mean
Posttest	Experimental	50	80.4800	10.33370	1.46141
	Control	50	76.1000	10.01275	1.41602

Independent samples test										
		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Posttest	Equal variances assumed	0.188	0.665	2.152	98	0.034	4.3800	2.03490	0.34181	8.41819
	Equal variances not assumed			2.152	97.903	0.034	4.3800	2.03490	0.34176	8.41824

Table 4: Comparison of test results in the experimental class.

Group statistics					
	Group	N	Mean	Std. deviation	Std. error mean
Experimental	Pretest	50	73.0500	10.01682	1.41659
	Posttest	50	80.4800	10.33370	1.46141

Independent samples test										
		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Experimental	Equal variances assumed	0.028	0.867	−3.036	98	0.003	−6.1800	2.03530	−10.21898	−2.14102
	Equal variances not assumed			−3.036	97.905	0.003	−6.1800	2.03530	−10.21903	−2.14097

Table 5: College students' sense of knowledge acquisition.

Options	Percentage (%)
(1) Learned the core values of knowledge of environmental protection	88.37
(2) Learned the basics of environmental protection and the analysis of environmental phenomena and problems	83.24
(3) Learned the relevant knowledge about the environment and deepened their understanding of the world we live in	78.89

established the correct view and strengthened their motivation in environmental protection, 78.29% of the students believe that they have formed a guiding role in enhancing the self-consciousnesses in environmental protection, 79.38% of the students believe that they have enhanced the sense of social responsibility, 65.73% of the students believe that they have the sense of sustainability for themselves, and 6.82% of the students say that they are not clear about what effect the study of environmental education courses has on your thinking. The survey results showed that we can draw good results from the overall thinking of the environmental education class and basically achieve the teaching goal of environmental education in colleges and universities.

In Table 7, the topic is can studying environmental courses change some of your daily behaviors? Only 25.69% thought that they completely will, 41.65% of the students chose basically will, 23.83% of the students chose "basically not," and 8.83% chose not to change their daily behavior at all. In the question what effects did the study of environmental education courses have on your behavior? 65.79% of the students said that through the study of the environmental education class, they could look at and deal with problems more rationally, and they could consciously resist bad temptations; and 72.35% of the students said that they could study diligently, love working, be diligent, and thrifty; 58.43% of the students said that they could take the initiative to stop it when encountered some bad behaviors; 48.79% of the students said that they were more actively involved in supporting environmental philanthropy. The study of ideological and political science has also had a certain impact

Table 6: College students' sense of emotion acquisition.

Options	Percentage (%)
(1) Established the correct view and strengthened their motivation for environmental protection	86.2
(2) Formed a guiding role in enhancing the self-consciousnesses in environmental protection	78.29
(3) Enhanced the sense of social responsibility	79.38
(4) Cultivated the sense of sustainability for themselves	65.73
(5) Not clear about what effect the study of environmental education course has on your thinking	6.82

Table 7: College students' sense of behavior acquisition.

Questions	Options and percentage			
Can studying environment courses change some of your daily behaviors?	Completely will (25.69%)	Basically will (41.65%)	Basically not (23.83%)	Completely not (8.83%)
What effects did the study of environmental education courses have on your behavior?	I could look at and deal with problems more rationally, and they could consciously resist bad temptations (65.79%)	I could study diligently, love working, be diligent, and thrifty (72.35%)	I could take the initiative to stop it when encountered some bad behaviors (58.43%)	I am actively involved in supporting environmental philanthropy (48.79%)

on the behavior of college students, and to a certain extent, it has changed the daily behavior of college students, but most students' sense of acquisition in behavior is obviously not as good as the sense of acquisition in knowledge and thought. It is reflected mainly in the change and acquisition of personal behavior, and the proportion of change in behavior is relatively low.

5. Conclusion

Environment courses are not only a realistic requirement for environmental education for contemporary college students but also an inevitable social requirement for college students. Enhancing the sense of environmental protection acquisition of college students in VR-supported environmental education courses can not only promote teaching and learning efficiency but also help college students shape a sound personality and cultivate college students with environmental protection and sustainable development awareness.

Most of the other VR educational applications focused on one ecosystem scenario or for certain groups of students, and most of them found positive results in improving academic and learning interests. Compared with other research, this research focused on experiential learning for general undergraduates. Therefore, the research results impressed the learning efficiency and sense of acquisition.

Through the investigation and analysis described above, we can find that VR-assisted environmental education is effective in improving student academic performance. Students' sense of acquisition in knowledge, thought, and behavior all improved to a different extent. The study found that the sense of acquisition of most students in the environmental learning class is mainly reflected in the knowledge and thinking aspects, and the sense of acquisition of environmental protection behavior is comparatively low, although it was also improved, which shows that the sense of acquisition of environmental learning of current college students is unbalanced. From the sense of knowledge acquisition to the sense of emotional acquisition and then externalized into the sense of behavior acquisition, it is not achieved overnight but gradually, so there is still a long way to go to achieve the balance and adequacy of the sense of acquisition of college students in environmental education classes.

During the teaching and learning process, students were more attracted to the experiential and immersive learning mode than to the traditional mode. It made the learning process more interesting, so the student's learning interest was also improved.

Furthermore, the time of this study is limited, and the VR scenario is also limited to eight, so it is necessary to further extend the VR scenario and expand the research subjects. With limitations to the present development of VR technology, the comfort of wearing VR glasses still exists. Therefore, further development of educational resources and exploration of the role of VR technology in environmental education are needed.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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