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Application of Digital Technology in Environmental Literacy Education for Teenagers

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Abstract. The purpose of this paper is to explore the effect of virtual environment based on digital technology in improving teenagers' environmental literacy level. By designing a control study, participants were divided into experimental group and control group with different environmental literacy education methods, and T-test was used to analyze and evaluate their environmental literacy level changes before and after the experiment. Interviews were conducted after the experiment to explore the intervention effect of virtual environment on the environmental literacy level of adolescents. After t test, both groups showed significant improvement in the comprehensive scores of environmental literacy assessment. Moreover, the difference of the experimental group was more significant than that of the control group, especially in environmental awareness, environmental attitude and environmental behavior. (***$p < 0.001$). The interview results show that 90% of the participants in the experimental group believe that the virtual environment provides a better learning experience and improves their learning efficiency. In contrast, 70% of participants in the control group believed that the content of regular education had brought them great benefits. The role of digital technology in environmental literacy education is significantly higher than that of conventional education group. This finding provides scientific support for the improvement and innovation of environmental literacy education, and can encourage the application of virtual digital technology in environmental literacy education.

Keywords. Digital technology, Virtual environment, VR, Environmental literacy, Environmental education

1. Introduction

Environmental literacy, as a multi-dimensional concept, includes the cognition, attitude, knowledge, skills and behavior of the environment. It is not just a discipline, but a way of life and values that are essential to the realization of sustainable development. R. Hooter et al. [1], define environmental literacy as knowledge and predisposition towards environmental (social-ecological) systems (e.g. environmental identification and self-efficacy, connection to nature), practices used in engaging with these systems (e.g. identifying issues, creating possible solutions), and resulting behaviours. As the successors of the future society, the improvement of teenagers' environmental literacy level plays an important role in the sustainable development of the society. A.Agfar et

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al. [2], using the sampling survey method, found that educational background has a relevant impact on the level of environmental literacy, and higher educational level has an advantage in the score of environmental literacy knowledge. The results of previous studies by NEETF published in the book Environmental Literacy in United States, education is the only factor that is most significant in influencing the level of literacy of the society environment. Environmental literacy education for young people aims to develop their sense of responsibility and critical thinking towards the environment so that they can better understand and respond to today's environmental challenges. However, the current environmental literacy education faces a series of challenges. Traditional approaches to education can be difficult to capture the keen interest of teenagers, especially in an age of information overload and distraction. M. S. Amin et al. [3] studied the environmental literacy level of younger students in schools in a city in West Java, Indonesia, and found that students in all schools had good environmental literacy categories, but most students said that they mainly learned about the environment from informal education (through family or home education). Even though environmental knowledge can be learned from both of school and home, but the practices and action was modelled at home. Not only that, the effects of education and learning motivation also need to be re-examined. How to make environmental literacy education more attractive and effective has become an urgent problem to be solved.

In the digital age, the rapid development of virtual digital technology has profoundly changed the face of the education field. This digital technology not only provides new opportunities for education, but also provides an opportunity to rethink the way and effectiveness of education. For example, in geography education, Kate R Jochecova et al. [4] carry out educational tasks in the form of VR interaction to help narrow the learning gap between students, provide more space for students to explore, and use gamification methods to stimulate students' learning enthusiasm.

Therefore, the purpose of this study is to explore the potential of virtual digital technology in improving the level of environmental literacy of adolescents. We will design a controlled study to divide teenagers into an experimental group and a control group to receive education based on virtual digital environment and traditional environmental literacy. Through this study, we hope to understand whether virtual digital technology can improve the level of environmental literacy of adolescents, and whether it can enhance learning motivation and improve educational results. The results of this study will contribute to the in-depth understanding of the role of virtual digital technology in environmental literacy education, and have the opportunity to provide a richer, deeper and interesting educational experience for teenagers' environmental literacy level, and provide scientific support for the improvement and innovation of environmental literacy education. By better understanding and harnessing the power of digital technologies, we are expected to contribute to the development of future generations with a high degree of environmental responsibility, make a greater contribution to the sustainable development of society in the future, inject new vitality into the cause of environmental protection, and thus move society towards a sustainable future.

2. Related work

Virtual digital environment A virtual space that simulates the real world or creates a new world through digital technology. It usually includes virtual reality (VR),

augmented reality (AR), virtual social platforms, simulators and many other forms. In the education system, the virtual digital environment has huge potential advantages. The technology is capable of simulating a variety of different natural and social environments, allowing learners to explore and experiment in a safe, virtual environment without negatively impacting the real world. The virtual digital environment is also highly interactive, which can actively participate in learners and improve emotional communication. Through the immersion, multimedia elements and interaction in the virtual environment, learners' emotional participation can be better stimulated and their sense of participation and involvement in learning can be improved. In addition, through personalized education, self-directed learning and real-time feedback, it can also improve the attractiveness of learning for them, stimulate their learning interest and initiative. Most importantly, they provide a platform for creative and interdisciplinary learning, encouraging learners to think about environmental issues from multiple perspectives and developing comprehensive literacy.

In the medical field, Omar Vayani et al. [5] found through an 11-week study that a virtual cancer research education program can be as effective as an in-person or hybrid program for research education although it may be suboptimal for learning about clinical oncology. Park and Kim [6] evaluated nursing education in a virtual environment simulation, which was also statistically significant. In the field of ecological environment, Antonio Lopez [7] 's research connects environmental and digital media education with the guiding metaphor of water, explores ecological media literacy, and prompts students to use four areas of inquiry: ecoculture, political ecology, ecomateriality, and the lifeworld to conduct holistic analysis and systematic thinking on gadgets. Explored how it impacts sensory, cognitive, and emotional experience. In terms of art exhibitions, Wang et al. [8] designed a VR exhibition platform to gain rich art experience through remote appreciation of artworks, thus promoting physical and mental health. Virtual environment education has also been used in performance and career self-efficacy assessment [9]. Some gamified virtual environment education also provides us with strong support and reference. Sobota et al. [10] designed a 3D virtual environment for children with multiple disabilities to learn, work and play in a virtual place. In the study of Kerstin Bissinger et al. [11], three-dimensional knowledge, environmental attitudes and pro-environment behaviors were introduced into the environmental literacy model, and through the combination of student-centered practical activities and autonomous learning, interventions focusing on tropical rainforest and climate change were implemented in botanical gardens to quantify the scores of individual knowledge, attitudes and behaviors. By comparing the intervention group and the test-retest group, it was found that knowledge acquisition, positive development of the self-concept of natural integration, and increased willingness to pro-environmental behaviors even encouraged environmental literacy. If a virtual environment based on environmental literacy education can be designed to allow students to personally experience different ecosystems, climate change and environmental challenges, students can have a deeper understanding of the complexity of climate change and ecosystems, and have a deeper sense of engagement and emotional experience. In this regard, the use of gamified education, through the way of games can cultivate students' environmental awareness and problem-solving ability, improve learners' environmental awareness and sustainable behavior. These studies and cases provide strong support and reference for future environmental literacy education.

3. Experiment design

3.1. Sample settings

In this study, we recruited participants from four different communities in Honggutan District, Nanchang City, Jiangxi Province, China through the platform publicity, and randomly selected 20 adolescents aged 12-18 to participate in the environmental literacy education project. Participants will voluntarily participate in the study according to their interests and sign informed consent, the experiment has secured the consent of students and their parents, and guaranteed that their information and privacy are properly protected.

3.2. Environmental Literacy Assessment Scale

Environmental literacy is a multi-dimensional concept. Therefore, according to previous studies on environmental literacy scale [12]–[15], we developed a comprehensive environmental literacy assessment scale, which consists of four items: environmental knowledge (25%), environmental awareness (25%), environmental attitude (25%) and environmental behavior (25%). Each item has five questions. A total of 20 questions are scored according to the participants' answers, with 1-5 points for each question, ranging from 20 to 100. We will assess the level and change of the participants' environmental literacy based on their scores on the Environmental Literacy Assessment Scale.

3.3. Experiment process

This study was conducted in two separate rooms in the Children's Palace of the newly built center in Nanchang City, Jiangxi Province. One room per group, with one researcher and ten participants in each room. Each participant in the experimental group was equipped with an Oculus Quest 2 HMD (Qualcomm®Snapdragon™XR2 platform, Adreno 650 graphics unit, 6GB RAM) and two controllers. There is also a computer in the room to record collaborative tasks in the virtual digital environment, and a device to demonstrate projective effects. The participants in the control group were taught environmental education content by professional teachers.

Before the experiment began, the participants were assessed on their level of environmental literacy, and each participant's score was recorded. At the start of the experiment, participants will be randomly divided into an experimental group and a control group, with half of each group being male or female. The experimental group received virtual digital environmental theme education, while the control group received lectures and discussions with traditional educational methods, covering the educational content of environmental literacy, such as environmental protection, environmental hazards, sustainable lifestyle, etc., to ensure that the educational content received by the experimental group and the control group was as consistent as possible. Each week, the scene changes according to the theme of environmental literacy, including ocean, forest, city and wilderness, etc., and participants interact and learn related knowledge through equipment and virtual environments. The experiment lasted for six weeks and was conducted once a week for two hours on Sundays. At the end of the experiment, both groups of participants were assessed again for their environmental

literacy levels, and each participant's assessment score was recorded. Figure 1 shows an example of a VR scene.

Figure 1. VR scene picture examples (sea, grassland, beach, city, park, field).

3.4. Data analysis

The study's quantitative data used T-testing and ANOVA to compare the two groups' environmental ethics scores before and after the experiment to determine the significance of the educational effect. As shown in Table 1, the basic characteristics of the two groups of participants showed no significant differences in their age, gender, education level and environmental literacy level assessment before the experiment.

Table 1. Basic characteristics of both groups of participants

Characteristic	Control group (n=10)	VR group (n=10)	t/X^2	P
Age	14.1 ± 1.66	14.9 ± 1.66	−1.075	0.296
Gender (n,%)			0	1
Male	5 (50.0)	5 (50.0)		

Female	5 (50.0)	5 (50.0)		
Education Degree (n,%)			0.202	0.653
Junior high school	6 (60.0)	5 (50.0)		
Senior high school	4 (40.0)	5 (50.0)		
Environmental Literacy	66.7 ± 4.27	66.1 ± 7.43	0.221	0.827

*ρ<0.05, **ρ<0.01, ***ρ<0.001

4. Results

After a 6-week educational experiment, we obtained the statistical changes of environmental literacy assessment scores of the two groups before and after the experiment, as shown in Table 2.

Table 2. Analysis of T-test of environmental literacy scale

Factor score	Control group (n=10)	VR group (n=10)
Total points	70.15±5.02***	71.95±2.35***
Environmental Knowledge	18.25±2.10(0.004)**	18.90±2.69(0.004)**
Environmental Awareness	18.35±2.03(0.016)*	18.50±2.46(0.001)***
Environmental Attitude	18.40±1.19(0.019)*	18.70±2.11(0.001)***
Environmental Behavior	15.05±1.40(0.154)	15.75±1.77(0.001)***

As shown in Table 2, by comparing the data before and after the experiment, it can be found that both the experimental group and the control group have the effect of improving environmental literacy. However, the degree of improvement in the two groups and the items that improved were different. The control group had a strong improvement effect on environmental knowledge (**p=0.004<0.01), and had a certain improvement effect on environmental awareness and environmental attitude (*p=0.016, p=0.019<0.05), but no significant improvement on environmental behavior (p=0.154). The experimental group had a strong improvement effect on environmental knowledge (**p=0.004<0.01), and a significant improvement effect on environmental awareness, environmental attitude, and environmental behavior (***p=0.001).

As can be seen in Table 2, in terms of improving environmental knowledge, the control group had the same effect as the experimental group, but in terms of improving environmental awareness and attitude, the experimental group was more significant than the control group, especially in improving environmental behavior. At the same time, we also noticed that the environmental behavior scores of the two groups were lower than those of other projects, and how to improve environmental behavior is also a issue worthy of attention.

Table 3. Participants' perceptions after the experiment (n=20)

Item	Control group (n=10)		VR group (n=10)	
	Yes N(%)	No N(%)	Yes N(%)	No N(%)
Learned a lot of knowledge	7(70.0)	3(30.0)	7(70.0)	3(30.0)
Improve the learning efficiency	5(50.0)	5(50.0)	8(80.0)	2(20.0)
Promote more interest in learning	5(50.0)	5(50.0)	7(80.0)	3(20.0)

Good experience	4(40.0)	6(60.0)	9(90.0)	1(10.0)
Sense of substitution	3(30.0)	7(70.0)	8(80.0)	2(20.0)
Emotional resonance	4(40.0)	6(60.0)	8(80.0)	2(20.0)
Emotional satisfaction	3(30.0)	7(70.0)	6(60.0)	4(40.0)

Table 3 shows the interview summary after the experiment. Both groups of participants learned a lot through this experiment, but in terms of improving learning efficiency and learning interest, the experimental group had a higher affirmative answer rate. In addition, participants in the experimental group also had a better learning experience, reporting higher emotional experiences and engagement in the virtual digital environment. They described feeling excited, curious and engaged in a virtual digital environment. One participant said: "The interaction in the virtual environment made me feel like I was really exploring new places. It makes learning fun." 90% of the participants in the experimental group believed that the virtual environment provided a better learning experience, improved their learning efficiency, and helped them better understand and remember information related to the environment. They emphasized the interactive and experimental nature of virtual digital environments, which prompted them to think more deeply about environmental issues. One participant said: "The actual experience in the virtual environment gave me a better understanding of climate change, more convincing than the knowledge on paper." In contrast, 70% of participants in the control group believed that the content of regular education had brought them great benefits. One participant said, "This activity has benefited me a lot, exposing me to knowledge that is not normally available in textbooks." The results of the interview show that the virtual digital environment has a significant positive impact on teenagers' environmental literacy education. Not only is the level of environmental literacy improved, but learning motivation and emotional experience are also stimulated. It is highly interactive, interesting and arouses emotional resonance, which can stimulate learners' participation to the greatest extent. Participants can enhance the depth and effect of learning through emotional communication, emotional engagement and emotional satisfaction. These findings highlight the potential of virtual digital technologies in education, especially in areas that involve complex topics and emotional engagement. This research provides scientific support for promoting the improvement and innovation of environmental literacy education, and is expected to encourage the wide application of virtual digital technology in education.

5. Discussion

The results of this study show that virtual digital technology has significant advantages in environmental literacy education. Participants in the experimental group received education in the virtual digital environment significantly improved their level of environmental literacy, learning motivation was enhanced, and emotional experience was richer. These results highlight the potential value of virtual digital technologies in environmental literacy education for adolescents. Not only that, the virtual digital environment provides learners with a more engaging and immersive learning experience. By simulating various environmental situations, learners are able to experience environmental challenges firsthand, thus gaining a deeper understanding and sense of the urgency of environmental issues. In addition, the interactive and

experimental nature of the virtual digital environment stimulates learners' initiative and enhances their learning motivation. Learners' emotional involvement and active participation in the virtual environment contribute to better absorbing knowledge and developing environmental awareness.

However, there are some limitations to consider in this study. In terms of sample selection, there may be some bias because we only selected adolescents aged 12 to 18 as participants. Future studies could expand the sample to include participants of different ages and education levels to obtain more comprehensive data. In addition, due to the short time span of the study, only environmental literacy assessment before and after the experiment was covered. Long-term follow-up studies may help to better understand the long-term impact of virtual digital environments on environmental literacy. The biggest hurdle is implementing virtual reality in schools. Due to the need for logistical maintenance and arranging enough classroom space, it is difficult to ensure that teachers are willing to use the method. It may not be easy to solve this problem because it seems to have more to do with the progress of technology and the motivation of teachers to teach.

In the future research, we can consider some personalized learning paths to meet the needs of different learners, better stimulate learning interest and improve learning results. Follow-up studies on the long-term effects of experiments to assess the long-term impact of virtual digital environments on environmental literacy will help determine the sustainability of virtual digital technologies in education. Based on virtual environment technology, it promotes interdisciplinary education, provides a good platform for interdisciplinary education, and enables learners to understand environmental issues more comprehensively. The application of virtual digital technology in environmental literacy education has great potential, which should be further explored in future research and practice.

6. Conclusion

The purpose of this study is to explore the potential role of virtual digital technology in improving teenagers' environmental literacy education. Through a controlled study, we found that virtual digital environments have great advantages in education.

The education received by the participants in the experimental group in the virtual digital environment significantly improved their level of environmental literacy, enhanced their learning motivation, and enriched their emotional experience. These results emphasize the importance and application prospect of virtual digital technology in the environmental literacy education of adolescents. Virtual digital environments provide learners with a more engaging and immersive learning experience. By simulating various environmental situations, learners are able to experience environmental challenges firsthand and gain a deeper understanding and sense of the urgency of environmental issues. This interactive and experimental nature stimulates learners' initiative and enhances their learning motivation. Learners' emotional involvement and active participation in the virtual environment contribute to better absorbing knowledge and developing environmental awareness.

The application of virtual digital technology in environmental literacy education is expected to promote educational reform and innovation. Future research and practice should further explore the potential of virtual digital technologies for personalized learning, long-term outcomes, interdisciplinary education, and educational policy

support. The continuous development of this field will help to provide youth with a richer, deeper and interesting environmental literacy educational experience, thus making a greater contribution to the sustainable development of society in the future. The application prospect of virtual digital technology is full of confidence, and it is expected to become an important innovative tool for environmental literacy education.

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