Research on the Curriculum Development of Education for Sustainable Development (ESD) from the Perspective of VR / AR assisted instruction——Take Guangdong Business and Technology University as an Example

Xin Yun Du¹ and Yi Bo Guan² and Tsung Shun Hsieh³

¹ College of Art, Guangdong Business and Technology University, Duanzhou District, Zhaoqing City, Guangdong Province, China
² College of Computer Application Technology, Guangdong Business and Technology University, Duanzhou District, Zhaoqing City, Guangdong Province, China
³ Krirk University, Thanon Ram Intra, Khwaeng Anusawari, Khet Bang Khen, Krung Thep Maha Nakhon 10220, Thailand

E-mail: 642599133@qq.cm

Abstract. On September 25, 2015, the United Nations Sustainable Development Summit adopted the 2030 Agenda for sustainable development. Education, as one of these goals, is an important way to achieve sustainable development, the function and responsibility of Universities to foster sustainable development should be emphasized. About the curriculum development of Education of Sustainable Development (ESD), along with VR/AR virtual reality equipment technology getting gradually mature, it is a trend that VR/AR equipment used in the class of universities. Based on this background, we proposed two questions: how to integrate VR/AR equipment into ESD teaching and learning? Does the VR/AR device hybrid model have a significant impact on the effects of the ESD course? A total of 46 sophomore students from Guangdong Business and Technology University were selected to participate in the quasi-course experiment. We conducted a questionnaire survey of students, used statistics analysis, compared the pre-test data with the post-test ones and interviewed a teacher. We concluded that VR/AR virtual reality equipment can be integrated into the curriculum of sustainable development. This teaching and learning model has a significant impact on students' grasp of the three dimensions: The cognitive, social emotional and the behavioral dimension of the curriculum of sustainable development. By integrating VR/AR into traditional classes, we can realize the virtualization of teaching environment and the liberalization of teaching space, further stimulate students' learning motivation and practical interest, and realize situational and immersive teaching and learning.
1. Research background

1.1 Sustainable development education

As the concept "Sustainable Development or Sustainability" first proposed, it has been one of the world's hottest topics [1]. "Transforming our World: The 2030 Agenda for Sustainable Development" was adopted by the United Nations Sustainable Development Summit on 25 September 2015. Depicted 17 sustainable development goals and 169 sub-goals in three dimensions: society, economy and environment, and pointed out that social inclusiveness, green economic growth and environmental protection are the three pillars of sustainable development in human societies. Education is an important way to achieve sustainable development [2], and the function and responsibility of University to foster these objectives should be emphasized. In many universities, the Education of Sustainable Development (ESD) curriculum is the pillar of sustainable development education. ESD emphasizes the core role of education in realizing sustainable development [3]. The three objective dimensions adapted from the Special Research Project Guidelines for ESD of UNESCO are cognitive dimension, social emotional dimension and behavioral dimension [4] (See Table 1).

| Dimension                      | Subject classification                                                                 |
|--------------------------------|----------------------------------------------------------------------------------------|
| Cognitive dimension            | Critical Thinking, Systematic Thinking, Holistic Thinking, Creative Thinking, Future Thinking. |
| Social emotional dimension     | Self-awareness, Justice, Responsibility, Democratic Participation, Respect for Diversity, Values of Tolerance Care, Compassion, Dialogue, Attitudes of Respect and Compassion, Solidarity, Global Solidarity, Cosmopolitanism, Anti-discrimination, Anti-racism, etc. |
| Behavioral dimension           | Problem-solving, Conflict Resolution, Collaboration, Life skills, Environmentally Sustainable Lifestyles, Responsible Consumers, Civic Engagement, Service to the community, Volunteerism, etc. |

1.2 VR/AR virtual reality assisted teaching equipment

With the development of the times, the traditional classroom teaching method has gradually revealed some disadvantages. The Single approach of teacher language teaching has not been able to content students' great demand for knowledge, which limits the students' creative thinking to a certain extent and is not conducive to the cultivation of their interest in learning [5]. In the face of the continuous improvement of students' knowledge reserve and the demand of increasing their learning input, the application of VR/AR equipment in university teaching is an innovative combination. VR/AR assisted instruction brings new audio-visual and immersive learning experience, enriching students' learning method which are conducive to mobilizing their interest in learning as well as cultivating their subjective initiative in learning.
VR refers to Virtual Reality, which has become one of the hottest topics in the technology industry. The year 2016 is even called "the first year of VR" by the industry. Nowadays, the development of VR technology has become increasingly rational, stable and mature. VR makes use of a computer-generated simulation environment, with the help of helmet, data gloves and other equipment, to enable users to perceive and operate the virtual world in real time, and obtain immersive feeling [6]. The research found that VR application in teaching can let students have immersive learning experience, increase students' learning input and help to cultivate their thinking and innovation ability [7].

AR refers to Augmented Reality. The essential difference between AR and VR is that everything in VR is virtual, while AR consists of virtual and realistic themes so that two-dimensional images can achieve three-dimensional effect [8]. This technology can also be used in books to present 3D, video and other multimedia forms in paper or mobile terminals. This combination has subverted the traditional reading form, making fixed words or pictures "live" [9] and with more amenity. In recent years, the textbooks of AR technology are gradually approaching college classrooms. Compared with the traditional textbooks, these are able to show all-round pictures, which can zoom in and out locally and have intelligent recognition and other functions, bringing a lot of convenience to college teaching.

2. Research question
Based on the analysis of the above research, this paper focuses on “the curriculum development of Education of Sustainable Development from the perspective of VR / AR assisted instruction”. The research questions of this paper are as follows:

- How to combine AR/VR auxiliary equipment with the teaching of sustainable development education courses in colleges and universities?
- Whether AR/VR assisted instruction can promote the three dimensions (cognitive dimension, social emotional dimension and behavioral dimension) of sustainable development education for college students?

3. Research design and implementation
This course mainly focuses on sustainable development and uses AR/VR assisted instruction to provide students with an immersive learning experience. In order to verify the role of VR/AR in promoting students’ learning of ESD. This paper uses an experimental method to teach two parallel classes with two different teaching methods and finally compares and analyzes the learning effect of students in two classes through questionnaire statistics and interviews.

3.1 Curriculum design
Early stage curriculum design is mainly divided into six objectives: the curriculum objective dimensions, the curriculum learning content, the specific situation of students, VR equipment, AR textbook and basic information of teachers (See Figure 1).
3.1.1. Analysis of teaching objectives
The analysis of teaching objectives is to analyze the contents of the courses or teaching units to determine the knowledge module composition of learners. The goal dimension of ESD focuses on cognition, social emotion and behavior.

3.1.2. Learning content analysis
According to the three objective dimensions of sustainable development education curriculum, cognition, social emotion and behavior, the curriculum content is designed respectively. The cognition dimension mainly trains students' critical thinking and systematic thinking. The social emotional dimension mainly trains students' self-awareness, social responsibility and sense of justice. Finally, the behavioral dimension mainly trains students' problem-solving ability and how to live an environmentally sustainable lifestyle. The course is divided into three sessions, focusing on ESD with three topics close to life, namely "water resources", "garbage classification" and "species extinction".

3.1.3. Basic information of teachers
The name of the lecturer of this experimental course is Mr. Guan, who works in the Department of Computer Application Technology of Guangdong Business and Technology University. He is a computer engineer, a teacher in charge of a VR laboratory and has organized students to participate in VR teaching activities many times.

3.1.4. Learner characteristics analysis
Learner characteristics analysis focuses on the state of the learners’ intellectual development, learning ability and the knowledge structure of learners. The teaching object is class 1 and class 2 of product art design major of Art Design Department of Guangdong Business and Technology University. In the specific selection of classes, the author makes the following considerations: counts the basic number of people in each class, and the proportion of boys and girls, and makes a detailed investigation of the students in the class to understand the number and proportion of people who have been exposed to VR/AR equipment. Then conducts a pre-test on the students’ understanding of the relevant knowledge of ESD curriculum. According to the table, the average scores of the three dimensions of cognition,
emotion and behavior for sustainable development of the students in the two classes are close, which are 3.5 in class A and 3.63 in class B (See Table2).

### Table 2. Learner characteristics analysis

|                        | Class A | Class B |
|------------------------|---------|---------|
| The total number of    | 24      | 22      |
| boys                   | 13      | 11      |
| girls                  | 11      | 10      |
| Number of people who have used VR/AR | 3      | 5      |
| Sustainability questionnaire Survey average score | 3.5 | 3.63 |

3.1.5. VR / AR assisted instruction creation
VR / AR assisted instruction is mainly designed around immersive environment creation. The required equipment is generally computer-aided, VR wearable and has a virtual rendering program.

3.2 Course implementation process
Based on the previous design of curriculum, including curriculum objectives, curriculum learning content, learner characteristics, the information of teachers and VR/AR equipment creation. The teaching and implementation plan of sustainable development education curriculum are determined. The implementation of the course starts on October 9 2019, and the sophomores (Class 1 and Class 2 of product major) are taught in the form of public elective courses for three weeks, with two classes per week. The themes of the three courses are "water resources", "garbage classification" and "species extinction". Class A is located in VR/AR Innovation and Entrepreneurial Center (Figure 2, Ming Bian building, Guangdong Business and Technology University), and Class B is located in classroom 306, Ming Bian building.

![Figure 2. VR/AR Innovation and Entrepreneurial Center](image)

Class A is the experimental class, and the teaching mode for teachers is to explain content with VR/AR assisted instruction. The teaching contents are "water resources", "garbage classification" and "species extinction". During the teaching process, first, Mr. Guan explains the basic knowledge of sustainable development through PPT (Power Point), plays the video of environmental damage, introduces the basic status of global environmental damage, and makes students understand that it is urgent to protect the environment.
Furthermore, the teacher leads the students to enter the virtual world through VR assisted instruction and enter the virtual world through VR equipment (see Figure 3, 4). For example, in the theme course of "water resources", the students experienced the melting of glaciers and forest fires (see Figure 5). This allowed them to observe and feel that human beings are so small in the face of natural disasters. This process plays a positive role in arousing students' social emotional dimension. Students can also have interactive experience through mobile apps with AR functions. For example, in the theme course of "garbage classification", students can use mobile apps to scan different kinds of garbage and learn how to effectively classify garbage through AR recognition (see Figure 6). Mr. Guan encouraged students to experience VR/AR equipment by asking questions, and encouraged students to think for themselves. Finally, Mr. Guan gave in-depth explanation and guidance on the three dimensions of sustainable development.

Class B is the experimental control class. The teaching mode is the traditional teaching method. It is mainly composed of the teacher explaining orally, combined with multimedia sources and text auxiliary materials. The course content is the same as the experimental class. The teaching process is that teachers guide students into the course through PPT, and explains the basic knowledge, plays course related images and explains relevant course content. During the teaching process, the teacher communicates with the students through questions or discussions to help them understand the three objective dimensions of ESD.

4. Research results

After class effect discussion based on VR / AR assisted instruction teaching design mode includes three parts: course effect analysis, analysis by synthesis and suggestion prospect, which are described respectively below.
4.1 Course effect analysis
Around the two research questions raised in this paper, by comparing the data of students’ pre-test and post-test, as well as the interview content of teachers. This paper analyzes and discusses the learning effect of students and research questions that are raised above.

At the end of the third course of the two classes, a second questionnaire survey is conducted on all the participating students, which is carried out from three dimensions of sustainable development, 20 questions in the cognitive dimension, 15 questions in the social emotional dimension and 15 questions in the behavioral dimension. The average scores of the three dimensions of ESD of the students in the two classes are obtained by the post-test questionnaire, as shown in Table 5 and 6.

According to Figure 7, it can be concluded that before the implementation of the ESD curriculum experiment, the results of the three dimensions of cognition, emotion and behavior of the two classes are nearly the same. It shows that the students in the two classes have the same understanding of sustainable development, and there is no significant difference.

The bar chart in Figure 8 shows that after the implementation of the course teaching, Class A is the experimental class and VR/AR equipment is used to assist the teaching; Class B uses the traditional teaching mode. Comparing the results of three dimensions of ESD content of students in two classes, the average score of class A is higher than that of class B in three dimensions. This result proves that Virtual Reality Equipment Assisted Instruction has significant effect on ESD, especially in social emotional dimension.

After the end of the course, the author conducted an interview with Mr. Guan, who taught the course. The interview content focused on whether the curriculum objectives of ESD are delivered, whether the teaching content is reasonable, the use of VR/AR auxiliary teaching equipment and the students’ classroom learning.

Author: Mr. Guan, would you please tell me, after the three special courses of ESD, how do the students react in the course of class?

Mr. Guan: The students in class A are very active during the class. Everyone wants to try VR equipment. Everyone is interested in emerging technology products. For the problems I put forward, they can explore through VR/AR assisted instruction and solve the problems by independent thinking. The students of class B behaved in the same way as usual. When I was lecturing on the platform, it is inevitable that some students will doze off or slip out. The reason for this may be that the students insist the teacher is instilling knowledge to them all the time, and they have no desire to explore by themselves.

Author: Mr. Guan, do you have any teaching experience to share in VR/AR equipment application in teaching?

Mr. Guan: From the teaching situation of the two classes, it can be seen that the effect of using virtual equipment to combine teaching will be better. First, students are very interested in new technology products, and each student wants to experience them, which increases their interest in
learning. Second, under the VR/AR assisted instruction, the original boring knowledge is transformed into a scene that can interact with students, making the knowledge more three-dimensional and closer to the actual life of students. Students can learn more from their own explorations and the memory points will be more profound.

The above is an excerpt of the interview content. From the interview record of Mr. Guan, the following points can be analyzed: First and foremost, the teaching form of VR/AR equipment into the teaching is very novel, the introduction of VR technology has aroused students' interest in learning and students can actively participate in teaching activities. Furthermore, through VR/AR auxiliary equipment, students can explore knowledge mysteries in VR environment and acquire new knowledge independently. This kind of teaching mode has a significant effect on cultivating students' critical, systematic and overall thinking. Last but not least, with the intervention of VR/AR auxiliary teaching equipment, the original boring book knowledge becomes vivid, which is conducive to the mastery of diversified knowledge.

4.2 Comprehensive analysis

Through the above analysis, it can be found that VR/AR is added to the curriculum of sustainable development education. This new teaching model is conducive to cultivating students to form the three dimensions of sustainable development education. For teaching in other fields, there are also preliminary findings as follows:

1. Virtualization of teaching environment

In traditional teaching, it is often limited by teaching conditions. However, with VR/AR auxiliary equipment, virtual instrument equipment and virtual laboratory can be set up on the computer, and the environment of practical teaching can be optimized. In addition, it can better solve the problems of site limitation, instrument equipment loss, enrich practical teaching content, and improve the efficiency of practical teaching.

2. Liberalization of teaching time and space

The application of VR/AR assisted instruction can break through the limitation of teaching time and space, provide specific objects and events (such as past, present and future) at any time and place, and realize the separate presentation or organic combination of teaching content and virtual environment. At the same time, from the perspective of students, they can enter the learning environment at any time without the limitation of time and space, and give play to the initiative of learning subjects in independent exploration.

3. Further stimulate learning motivation and practical interest

The VR/AR auxiliary equipment can achieve the functions of sound, picture and text simultaneously, which greatly improves the students' perception level. VR/AR auxiliary devices create realistic learning scenes, enhance the sense of immersion in learning, and bring learners a positive mood of relaxation, pleasure and fun, which is conducive to stimulate learners' interest in active learning.

4. Realize situational teaching

A realistic learning situation can be created through VR/AR technology. Students can actively construct knowledge in the virtual learning situation. For example, VR/AR technology can be used to restore historical events and situations so that students can experience the situation in person. This allows them to deeply understand the relevant historical knowledge in textbooks.

4.3 Suggestions and prospects

VR/AR assisted instruction teaching mode is still in the initial stage, whether in practice or in theory, there is a lot of space to explore. The following are three suggestions for further study:

1. Teacher training. VR/AR equipment is a high-tech product, which is not popular at present so there is a technical threshold for teachers to contact such equipment. Therefore, how to train teachers and make them have the ability to use virtual equipment will be a key issue before the virtual reality combined teaching mode is implemented in schools.
2. Course content. Based on the characteristics of VR/AR equipment, how to combine course objectives, course content and virtual equipment and how to give full play to the best effect are also the focus of future discussion.

3. New technology adaptation. The adaptation speed of students to VR/AR equipment and the adaptation difference of different students to the equipment will affect the learning of students in this new teaching mode. Therefore, how to eliminate the strangeness between human and computer, help students quickly adapt to VR/AR equipment and make teaching practice more real and perfect. More research will be done on this topic.

With the progress of science and technology and rapid development of the new media industry, the current market VR / AR products are increasingly mature, with the continuous improvement of technical aspects as well as the gradual decline of equipment costs, its application in classroom teaching is imminent. It is a new breakthrough to combine virtual reality equipment with teaching, and it will also usher in the innovation of teaching means and the introduction of teaching mode into a new era.

References

[1] UNESCO 2018 Global Action Programme on Education for Sustainable Development
https://en.unesco.org/globalactionprogrammeoneducation

[2] Zhang J Z 2011 The Features and Inspirations of Sustainability Curriculum Framework of Australia Curriculum Teaching Material and Method 31(4) 97

[3] Qian L X 2005 Strategies and implementation recommendations for the United Nations decade of education for sustainable development Global Education 34(11) 11

[4] Huang Z J, Wu J and Tang L 2019 How Far is China's Present Education from the Education for Sustainable Development in 2030—Based on an Analysis of the Curriculum Standards for Compulsory Education Educ. Res. 429(2) 142

[5] Wang M 2012 Basic to VR display and interactive teaching system design and realization (Master's thesis) Available from CNKI (China National Knowledge Infrastructure)

[6] Burdea G and Coiffet P 1994 Virtual Reality Technology (New York: John Wiley & Sons)

[7] Xu H Z 2018 Practice exploration of immersive teaching based on VR (Master's thesis) Available from CNKI (China National Knowledge Infrastructure)

[8-9] Mao J 2017 Application of College P.E. Based on VR, AR and MR J. of Wuhan Institute of Phys. Educ. 51(9) 77