

The Design of 3D-Virtual Learning Environments in the View of System Theory*

Jianming Wang
School of Art & Design
SIAS University
Zhengzhou, China 451150

Abstract—With the deep application of virtual reality technology and 3D-simulation technology in education, virtual learning environment has begun to develop from 2D-virtual learning environments to 3D-virtual learning environments. 3D-virtual learning environments have become a hot research. Based on research results in China and foreign countries, we detailedly discuss the guiding function of systems theory’s general principles, feedback principles and ordering principles on building 3D-virtual learning environments. On this basis, we design the theory model of 3D-virtual learning environments, and we elaborate the key factors of 3D-virtual learning environments, to provide theoretical guidance for the construction of our country’s 3D-virtual learning environments.

Keywords: 3D-virtual learning environments, system theory, design

I. INTRODUCTION

In recent years, three-dimensional virtual learning environment has become a hot spot of current network learning environment research. 3D Virtual Learning Environments (3D-vles) is also called 3D Virtual Learning Community. It refers to the virtual learning world developed by using 3D modeling technology and virtual reality technology, integrating subject knowledge and playing. It allows multiple participants to join in at the same time by using computers, explore complex virtual world by using interactive exploration tools, collect data from embedded visual objects that imitate the real world, communicate with other participants and computer intelligent agents, and participate in various types of cooperative learning activities [1]. Because it is displayed on the computer screen with the help of computer, and is different from the 3D environment with stronger immersion with the help of virtual reality

equipment, it is also called 2.5D. However, compared with the two-dimensional virtual learning environment, 3D-vles has strong interactivity, immersion and imagination. Diversified information presentation, high fidelity and more interactive virtual environment can better stimulate students' interest, and the game based story ensures students' long-term participation in online learning.

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There are many successful cases of 3D-vles in education. For example, second life, which was launched by Linden laboratory in 2003, has become a leading virtual classroom in many universities, including Harvard University, Allen University, Ohio University, New York University, Stanford University, etc. River city and virtual Singapore are 3D VLEs based on middle school science curriculum developed in the United States and Singapore respectively in order to promote the non-good structure in science curriculum like study of domain knowledge, cultivate students' inquiry skills and knowledge transfer ability [2]. Quest Atlantis is a multi-user virtual learning environment of educational game nature hosted by Professor Sasha Barab of Indiana University. It is suitable for 9-12-year-old students. It integrates subject knowledge into the game situation according to course learning tasks, and enables students to explore learning in the virtual world by role-playing mode [3]. These empirical studies have had a positive impact on local education, and some of them have been promoted in a wide range of regions. This paper introduces the system theory into the three-dimensional virtual learning environment, and discusses the construction of the three-dimensional virtual learning environment from the perspective of the system theory.

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II. APPLICATION OF SYSTEM THEORY IN THE CONSTRUCTION OF 3D VIRTUAL LEARNING ENVIRONMENT

System theory was first put forward by Austrian biologist L.V. Bertalanffy, and then combined with cybernetics, information theory, synergism and hyper-cycle theory to form a relatively complete system science. System theory has a wide range of applications in many disciplines such as physics, chemistry, biology, and computer and so on. Similarly, system theory can also be introduced into the construction of 3D-vles. According to the system theory thought and system method, 3D-vles can be regarded as an organic whole. By analyzing the structure and function of 3D-vles, the overall architecture and systematic development process of its development can be constructed, so as to achieve optimization [4]. The main idea of system theory can be summarized as three basic principles: the whole principle, the feedback principle and the order principle. Three pieces of principle have potential guiding role in the construction of 3D-vles.

A. *The whole principle and the whole structure of 3D virtual learning environment*

The whole principle of the system refers to that any system can play the whole function only by forming the whole structure through mutual connection. The overall principle tells us that whether a 3D-vles can play a good role is not entirely due to how advanced the development technology is used. The key is whether it has the integrity and whether all parts can work together. 3D-vles includes teachers, students, teaching content, virtual environment and many other elements. These elements form 3D-vles system through interaction. Some scholars take ecology as the starting point and divide virtual learning environment into physical environment, social environment and normative environment from a macro perspective [5]. On this basis, we combine the thought of system theory to summarize it again and subdivide it. Physical environment refers to the hardware, software and information resources supporting virtual inquiry learning, which is the foundation and support of virtual learning environment; social environment refers to the relationship between teachers and students, the relationship between students and students formed in the process of virtual inquiry learning, which is the key factor affecting the learning effect; normative environment refers to the teacher's guidance in virtual learning environment Students' inquiry norms and intelligent agent help, etc. which restrict and guarantee the smooth progress of inquiry learning. According to the overall composition and function of 3D-vles, three environments can be divided into eight systems: hardware system, software system, and resource base system, teacher-student interaction system, student-student collaboration system, and intelligent agent system, help prompt system and platform operation specification system. Each subsystem is interrelated and indispensable. When designing 3D-vles, we should consider the design and organic integration of each subsystem, not just simple combination and accumulation, to ensure that "the overall function is greater than the sum of parts".

B. *Feedback principle and "five feedback models" of 3D virtual learning environment*

The feedback principle of a system means that only through feedback information can any system achieve effective control and achieve its goal. Feedback plays an important role in the system, which guarantees the two-way transmission of information in the process of inquiry learning, so that teachers and students can adjust teaching and learning strategies in time, so as to ensure good teaching effect. In 3D-vles, there are interactions between teachers and teachers, teachers and students, students and students, teachers and environment, and students and environment. Based on this, we propose a "five feedback model" of 3D-vles. There are five kinds of feedback modes in the system: teacher feedback, teacher-student feedback, student-student feedback, teacher environment feedback and student environment feedback. Five ways of feedback reflect the relationship between the elements in the system. Teacher-teacher feedback refers to the negotiation between teachers and students to organize students' exploration activities; teacher-student feedback refers to that in the process of students' exploration, students report the results of exploration and learning, problems encountered to teachers in time, and teachers give corresponding guidance and evaluation to students; student feedback refers to that students form a team In this way, the team members can help each other through communication and cooperation to make progress and complete tasks together. The feedback between students and the environment refers to that students carry out exploration activities in the virtual environment by operating the avatar, collect various data in different places, and send out request instructions to the virtual environment when they encounter problems. The virtual environment uses Intelligent agent system or help system provides help information for students; feedback between teachers and environment refers to that teachers and students have their own avatars in the virtual environment, through which teachers can participate in the virtual environment, monitor and provide guidance for students' research activities in real time, and teachers can also participate in anonymously to prevent Students are unable to play freely because of the existence of teachers.

C. *Order principle and virtual learning community*

The order principle of a system is also called "the principle of openness", which means that any system is an open process from simple disorder to advanced order. The ordered or disordered state of a system can be measured by "entropy". The more disordered, disordered and uncertain the system is, the greater the entropy will be; on the contrary, the less orderly and uncertain the system is, the smaller the entropy will be. According to the principle of entropy increase, in an isolated system, entropy always increases, so the system always tends to chaos and disorder automatically in an isolated situation. The principle of order emphasizes the openness of the system. From a macro point of view, 3D-vles is a large system. In order to make the virtual inquiry learning orderly and normal, it is necessary to ensure the openness and dynamic of the virtual environment, maintain continuous information exchange with the outside world, and

constantly modify and improve the system according to these information and feedback, and finally evolve into a high-level and orderly system; from a micro point of view In a word, there are several subsystems in 3D-vles, and each subsystem should be open and interconnected. Especially for the sub-system of the subject of inquiry learning, we can't stand on our own feet and build a car behind closed doors. We think that the importance of inquiry learning and collaborative learning should be emphasized in the construction of three-dimensional virtual environment, and a virtual learning community should be established. Virtual learning community refers to a learning group that teachers and students promote each other in the process of virtual inquiry learning, under the guidance of teachers, by controlling the "Avatar" in the virtual environment to complete certain tasks together. Students collect information from an open, chaotic and disordered environment, exchange and share learning results, and report learning results to teachers. Teachers give guidance in time, and students invest in inquiry learning according to teachers' feedback, so repeatedly, until inquiry problems are solved, forming an orderly and systematic knowledge system.

III. THEORETICAL MODEL CONSTRUCTION OF 3D VIRTUAL LEARNING ENVIRONMENT

According to the guiding role of the three principles of system theory in the construction of 3D-vles, we abstract and design the theoretical model framework of 3D-vles. As shown in "Fig. 1", this figure shows that 3D-vles is a dynamic and open system. Teachers and students control avatars in 3D-vles through computers respectively. They form a virtual learning community of 3D-vles. Members of the community follow the "two-way communication mechanism" to exchange information. In this framework, 3D-vles keeps close contact with the external environment and exchanges varied information dynamically. The subjects (teachers and students) in the virtual learning community are also in an open state. They communicate and cooperate according to the "five feedback model" to guide and answer questions. The three environments provide the possibility for the exploration activities, the teacher-student interaction system and the student-student cooperation system in the social environment provide the communication platform for teachers and students, the physical environment provides the support of hardware, software and resources for the virtual learning community, and the standardized environment restricts and guarantees the communication activities between teachers and students smoothly through the platform operation standardized system agent and help prompt system assist students' exploration activities.

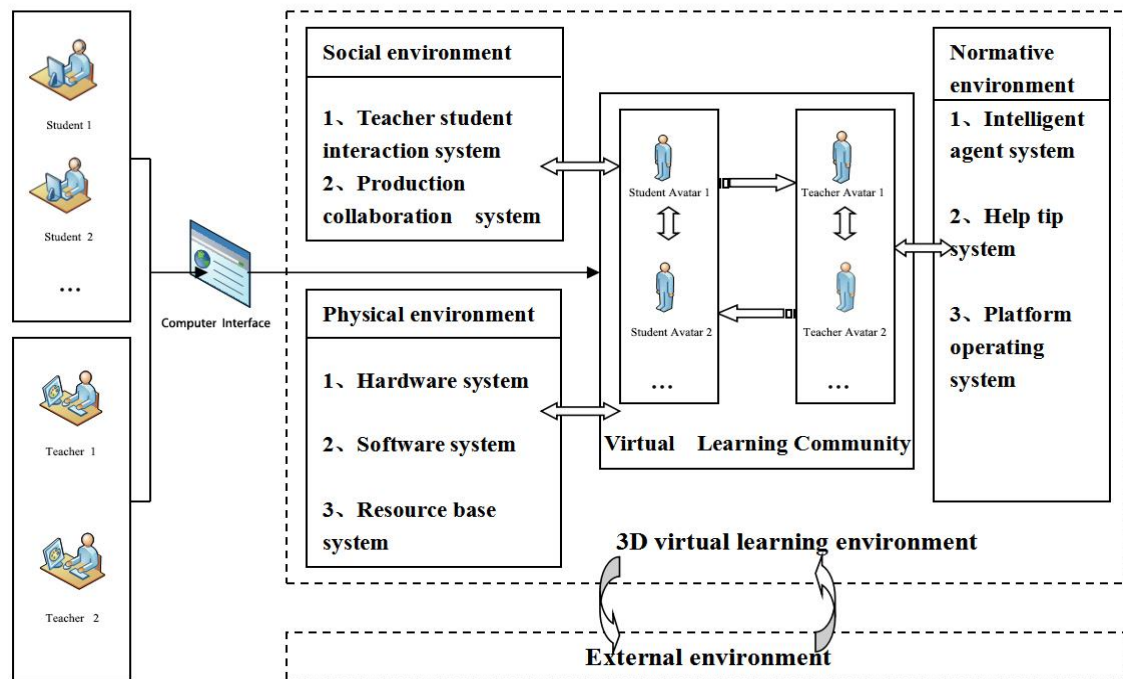


Fig. 1. Theoretical framework of 3d virtual learning environment.

The theoretical model framework diagram of 3D virtual learning environment shows the components and operation mode of 3D-vles as a whole. In addition, some key elements

should be paid attention to when building 3D-vles, mainly including the following points.

A. Soul of 3D virtual learning environment

Compared with the two-dimensional virtual learning environment, the advantages of 3D-vles lie in the diversity of its content presentation, stronger interaction and immersion. Therefore, to build a good 3D-vles, its own advantages should be highlighted. The "soul" of 3D-vles construction is to emphasize the richness of content and the diversity of presentation, the good interaction, immersion and ups and downs of the scene. As 3D-vles is a huge system composed of many elements, all elements and links affect the final effect of 3D-vles, so it is very complex and difficult to grasp the "soul" of 3D-vles. Therefore, we can learn from the development idea of online games, fully analyze the teaching content and learner characteristics, determine the type of teaching content, and select learning materials that conform to the learning style of students. It is also one of the key factors that whether 3D-vles can stimulate learners' interest in learning and maintain learning sustainability.

B. Blueprint of 3D virtual learning environment

Another key factor in building 3D-vles is "development plan", which is the overall planning of 3D-vles development, which is a "blueprint"; the development plan mainly includes development technology selection and development script writing. The success or failure of 3D-vles does not lie in the use of advanced technology, but in the selection of appropriate development platform and technology. The development technologies are mainly listed below.

1) *Platform development technology*: At present, platform development technology can be divided into open source and non-open source [6].

2) *Agent intelligent agent technology*: Intelligent agent technology refers to the process of collecting information or providing other related services. It does not need human intervention, and can create virtual intelligent agent role in 3D-vles.

3) *Teacher-student interaction technology*: The technology of teacher-student interaction mainly refers to the tools and communication methods used by teachers and students in the interaction process, including synchronous and asynchronous.

4) *Virtual exploration tools*: Virtual inquiry tools are mainly used to assist students in inquiry learning, such as virtual magnifying glass, virtual library, etc. Development technology is the support of the product, which determines the overall function of 3D-vles. Writing development script is one of the core elements of the development plan, which is a guiding document, including the detailed steps of 3D-vles construction and the precautions for each step, and is the direct basis for 3D-vles construction.

C. Evaluation dimension of 3D virtual learning environment

Evaluation is an important part of platform development and education application. Because of its complexity and operability, evaluation is often difficult to implement or ignored. In order to judge the application effect of 3D-vles in teaching, we can evaluate it from three dimensions: teachers, students and 3D-vles, as shown in "Table I".

TABLE I. EVALUATION DIMENSIONS OF 3D VIRTUAL LEARNING ENVIRONMENT

Three dimensions	Several problems
Teacher	<ul style="list-style-type: none"> •What is the teacher's attitude towards using 3D virtual learning environment? •Is the workload of teachers reduced compared with traditional teaching? •Can teachers participate in and guide students' inquiry activities for a long time?
Student	<ul style="list-style-type: none"> • How long does it last for students to participate in inquiry learning? • How often do students participate in inquiry activities? • What kind of students are more active in inquiry learning? • Do boys and girls perform the same in inquiry learning? • How about the students' team work? •How about the satisfaction and achievement of the students before and after the experiment? •Have the students' scores improved before and after the experiment? • How well did the students master the knowledge before and after the experiment?
3D-VLEs	<ul style="list-style-type: none"> • Is the navigation system clear and the interface easy to operate? • Can students be attracted to participate? • Are there various ways of interaction between teachers and students? •How effective is the agent intelligent agent and help system to support students?

It can be seen from the three-dimensional virtual learning environment evaluation table that the main dimension of evaluation is students. The application effect of 3D-vles in teaching can be judged intuitively through the changes of students' pre-test and post test scores, changes of students' behavior, changes of students' practical ability and ability to transfer knowledge. In addition, the teacher dimension and 3D-vles dimension also reflect the teaching application effect of 3D-vles from the side, for example, the attitude of teachers and the operability of 3D-vles all affect the

experimental results. The "evaluation dimension" also has a certain guiding role in the construction of 3D-vles. In the construction of 3D-vles, we should consider some problems in the "evaluation dimension" to build a more humanized 3D-vles.

IV. CONCLUSION

3D virtual learning environment is a new form of network learning environment. Because 3D virtual learning

environment has the advantages of high visualization, strong interest and diversified content presentation, it has inherent advantages in the virtual learning environment and can better support network inquiry learning and cooperative learning. In order to construct the 3D virtual learning environment, we should take the system theory as the guidance, combine the whole principle, feedback principle and order principle of the system theory with the 3D virtual learning environment, design the physical environment, social environment and planning environment of the 3D virtual learning environment as a whole, establish the feedback model, give full play to the role of the learning community, and pay attention to the "soul" of the 3D-vles construction "Blueprint" and "evaluation dimension". With the progress of computer technology, computer hardware and network bandwidth will no longer be the bottleneck restricting its development and application. 3D virtual learning environment will gradually become an ideal environment for future network learning and a powerful supplement to the real learning environment.

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