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Sewage Treatment Experiment Teaching System Based on Virtual Reality

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Abstract: A virtual reality experiment platform for sewage treatment is designed for some possible scenarios, such as distant field practice, time-consuming experiment process, unable to operate on site, setting changeable process parameters, dealing with occasional accidents and so on. The construction of the virtual reality experiment teaching system for sewage treatment is expounded from the aspects including teaching aims,the contents of experiment, teaching methods and assessments as well as the construction of the virtual reality experiment teaching system.

1. Preface

The "Opinions of the CPC Central Committee and State Council on Comprehensively Strengthening Ecological Environmental Protection and Resolutely Fighting the Battle of Pollution Prevention and Control" [1] issued by the Party Central Committee proposes that we must focus on the battle for the protection of blue water, deeply implement the action plan for water pollution prevention and control, solidly promote the river and lake system, adhere to the two-handed efforts of pollution reduction and ecological expansion, accelerate the improvement of industrial, agricultural and domestic pollution sources and water ecosystems, ensure the safety of drinking water, and Eliminate urban black smelly water bodies, reduce the pollution of serious water bodies and substandard water bodies. The water pollution control engineering as one of the core courses of environmental engineering, mainly to train students to apply the basic principles of pollution management, for different types of wastewater, according to different treatment methods, using different processes and equipment (structures) for pollution management capabilities. This course is a highly applied engineering course, and practical teaching is an important part of it. Traditional practical teaching mainly takes two modes; one is in the laboratory using small independent experimental teaching equipment, simulating a unit or a process, such as aeration biological contact oxidation ponds and other simulated real sewage treatment structures for sewage treatment. This way of teaching fragments the whole aspect of wastewater treatment into one unit, which is not conducive to cultivating students' holistic thinking. Moreover, the teaching method of adopting

model simulation is still different from reality. Another model is that students go to enterprises for internship. This mode of teaching is usually done in the form of visits, which is not conducive to students' in-depth understanding of the internal structure of the process, and cannot realize the site for process parameters and other control, management of the process and judgment when accidents occur, solutions are also not learned in the form of visits. Practical teaching reform ushered in a new opportunity for development.

Virtual simulation experimental teaching is relying on virtual simulation technology to build a highly simulated virtual experimental environment and experimental objects, and students carry out experiments in the virtual environment to achieve the teaching effect required by the syllabus [2]. Virtual simulation experimental teaching has the advantages of intuitive image, real experience, strong interactivity, and experimental teaching can be repeated, not limited by time and space, and can solve the problem of high-risk or extreme environment can not be experimental teaching, while for the high cost, high consumption, irreversible operation, involving life safety and other course content has a strong value for the promotion of application, so the application of broad prospects [3-13]. However, virtual simulation teaching at home and abroad is still in the exploratory stage, and there are few cases of virtual simulation experimental teaching about wastewater treatment. In view of this, the College of Environment and Resources of Fuzhou University relies on the provincial experimental teaching demonstration center, based on the rich experience of physical experimental teaching and students' deep learning needs, and uses various forms of virtual simulation technology to create a highly simulated and close to the real wastewater treatment virtual simulation experimental system.

2. Virtual Simulation Experimental Teaching System Construction

The primary goal of virtual simulation experimental teaching system development is to complete the teaching objectives and content, and then consider the application of modern information technology means to enhance the attractiveness of experimental teaching and teaching effectiveness. Therefore, the construction of virtual simulation experimental teaching system needs to start from the experimental teaching objectives, experimental content, teaching methods and experimental assessment, virtual simulation system construction and so on.

2.1 Experimental Teaching Objectives

Water pollution control engineering experimental course objective is to make students understand the basic principles of wastewater treatment process through the study of this course, mastering the principles of various treatment methods, calculation methods, structure construction and operation mode, characteristics, scope of application, the composition of the process flow and treatment efficiency. Students will have the ability to apply basic knowledge of natural sciences such as mathematics, chemistry, physics, and biology and professional knowledge of environmental engineering, to design and implement experimental programs, to analyze data, to synthesize information, and to have the ability to use the technologies, skills, and tools required for engineering practice and to engage in continuous learning. In order to achieve the teaching objectives, students need to learn further through experiments on the basis of theoretical learning, to link theory with practice and deepen their understanding of basic concepts and principles of water pollution control, for example, students can learn about the principle, operation, characteristics, scope of application and other related knowledge of the A2O process by clicking on the process introduction in the knowledge section of the virtual simulation system, see Figure 1. Experimental

platform, also provides a process video, see Figure 2, students watch, and then combined with the flow chart provided by the platform and the treatment site, students can establish a global understanding of the overall process of wastewater treatment. Students roaming in the virtual simulation of sewage treatment plant, you can observe the 3D water treatment structures such as filter ponds, and combined with the 2D profile, have an intuitive and comprehensive understanding of its structure, to avoid the site production practice when the water treatment structures are submerged in sewage or buried deep underground, can not show the situation. For equipment awareness learning, students through the virtual manual disassembly centrifugal pump link, master the structure of the equipment and installation methods, see Figure 3. treatment process exceptions such as low residual chlorine effluent, is to examine the students according to the professional knowledge of environmental engineering, through the existing data and information to analyze, design a feasible plan to change the relevant parameters, the ability to treat wastewater up to standards. There is also micro-lesson content on the virtual simulation system, see Figure 4, for students to expand and extend their learning.

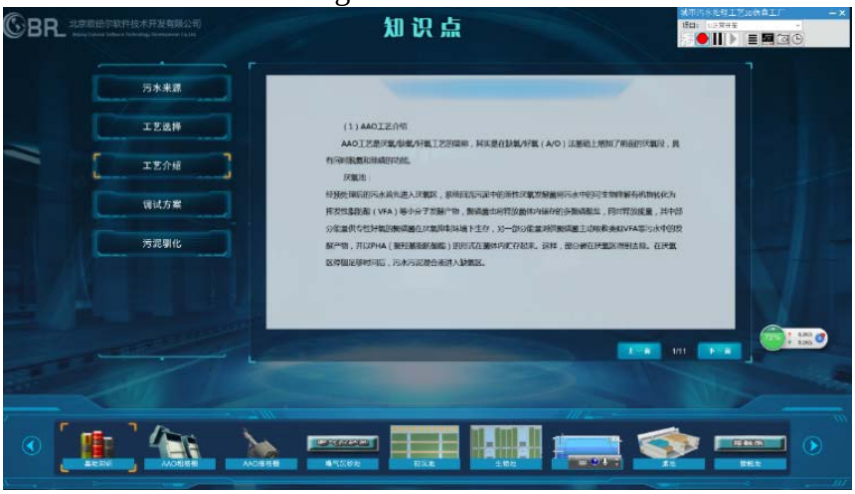

Figure1: Knowledge points.

Figure2: Process video.

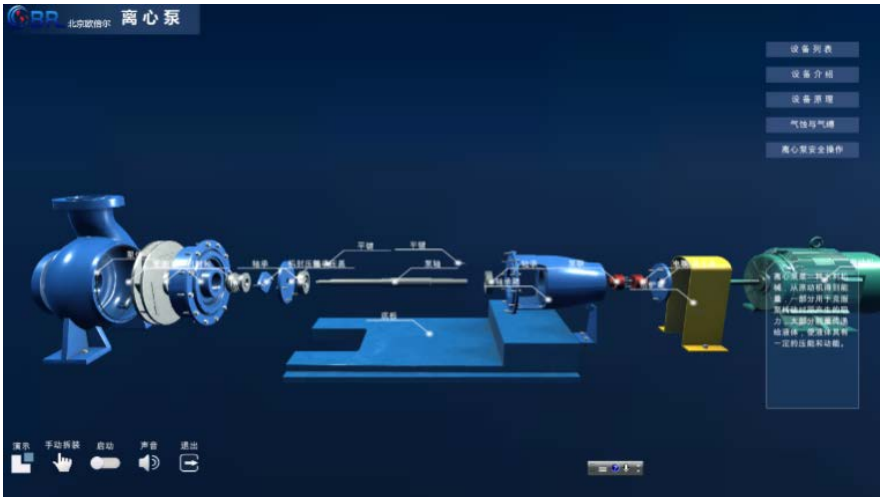

Figure3: Centrifugal Pump.

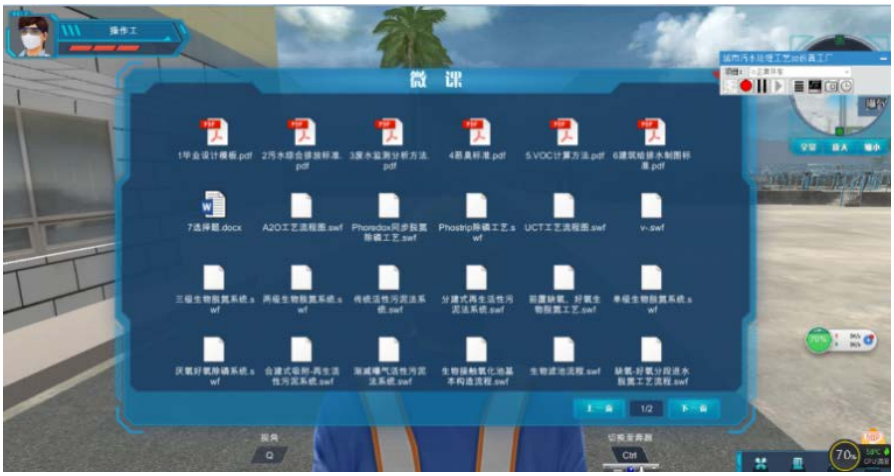

Figure 4: Microlecture.

2.2 Experimental Content Construction

Environmental engineering is the study of technologies for the prevention and control of environmental pollution and improvement of environmental quality, i.e., it mainly studies the prevention and control technologies for wastewater, waste gas, solid waste, noise and other pollution-causing substances such as radioactive substances, heat, electromagnetic waves, etc. Among them, wastewater treatment is an important part of environmental engineering research. Biological treatment is an important method of wastewater treatment, but due to the many factors affecting the biological treatment process and the long growth cycle, the traditional experiments cannot reproduce the complete process in the limited class time, and students' knowledge of biological treatment process is "fragmented". In the traditional practice mode, students can only see the appearance of the structure, but the specific internal structure is often blocked by the turbid sewage and cannot be recognized, and it is impossible to adjust the parameters set by the plant production. At the same time, the probability of an accident occurring in the equipment or process is small, and students cannot learn how to troubleshoot and solve problems. Therefore, in response to these problems, the construction of sewage treatment virtual simulation experimental system,

virtual simulation of sewage treatment plant environment, simulation of the whole process of sewage treatment, see Figure 5.

Sewage treatment virtual simulation experimental system based on the typical sewage treatment process A2O and AB process, through the sewage water quality monitoring, treatment process simulation, equipment monitoring simulation, accident abnormality treatment, 3D virtual field operation, the basic theory of sewage treatment, basic operation, equipment construction and other knowledge throughout the learning process, and the corresponding knowledge points are extracted by menu entry type organized, convenient for students to learn to understand, see Figure 1.

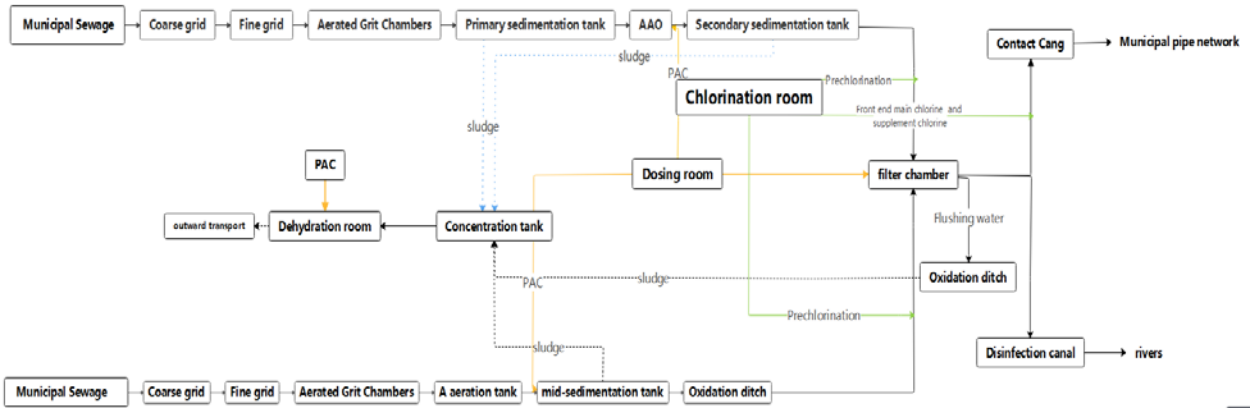

Figure 5: Flow chart.

2.3 Experimental Teaching Methods And Assessment

Traditional experimental teaching, with teacher teaching as the center, emphasizes students' understanding and memory of knowledge, while paying less attention to the application of knowledge, and it is difficult for students to apply the learned knowledge into reality after they graduate and take up the workplace. The use of wastewater treatment virtual simulation experimental teaching system can realize flipped teaching, student-centered, mobilize students' enthusiasm and motivate learning [14].

Figure 6: Experimental teaching tasks.

Before the class, students have a superficial understanding of the whole process of wastewater

treatment and the knowledge of each link of the process through the pre-study of the treatment process video and related knowledge points; during the course, students are immersed in the virtual wastewater treatment plant environment, simulating real operators to operate the equipment and change the process conditions, so as to complete the tasks, see Figure 6, and finally realize the internalization and application of the knowledge in the class and complete in-depth learning.

The experimental assessment at the end of the laboratory course is divided into two parts, namely, operational skills and theoretical knowledge assessment. Among them, operational skills are the focus of the assessment. The operation sequence of the process, operation time, whether the operation is standardized and the selection and processing of experimental parameters are the main basis for the scoring of the operation skills assessment, see Figure 7. The teacher can call the test bank in the platform and select the relevant test questions for assessment.

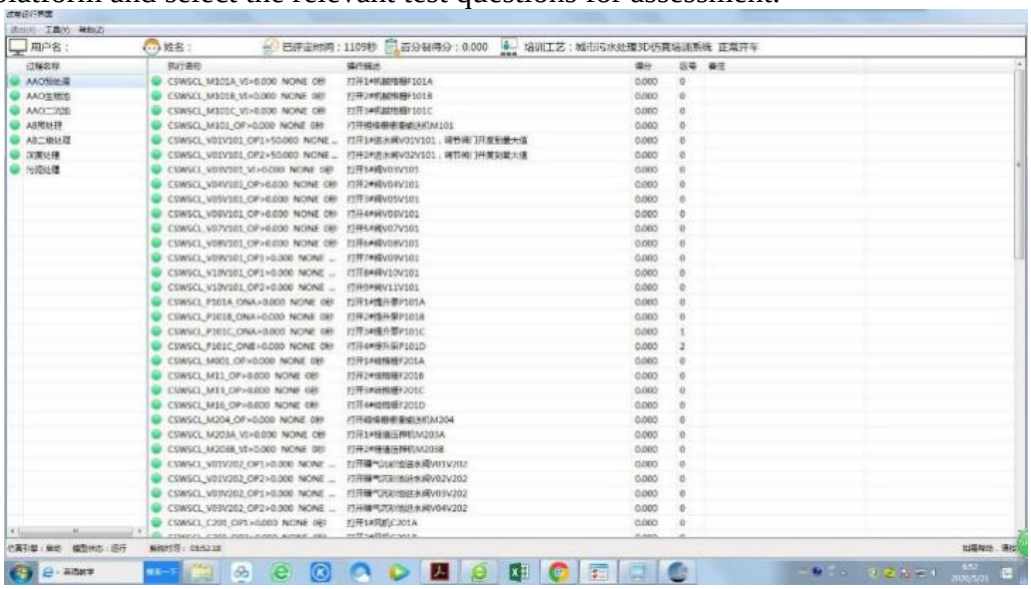

Figure 7: Assessment and scoring system.

2.4 Virtual Simulation Experimental Teaching Platform Construction

The main organizational framework of the platform is shown in Figure 8, which mainly serves teachers, students and system administrators. Through the virtual simulation teaching platform, teachers can upload and modify the question bank, enrich the courseware resources, call simulation software and so on to realize the resource management; in the course management, you can enter the simulation experiment course and other experiment courses, so as to help teachers can clearly understand the course arrangement situation and specific progress. The class management function can realize student management, online question and answer for students, and examination results statistics; examination management realizes online examination correction and other functions. Students can log into the Personal Center to modify their personal information and browse their past learning history; the Resource Center allows online learning of existing resources; the Course Center contains course announcements, online simulations, lab reports, discussion and Q&A, online experiments and other functions; students log into the Exam Center to take online exams during exams; the system administrator mainly manages organizations, personnel, permissions and logs.

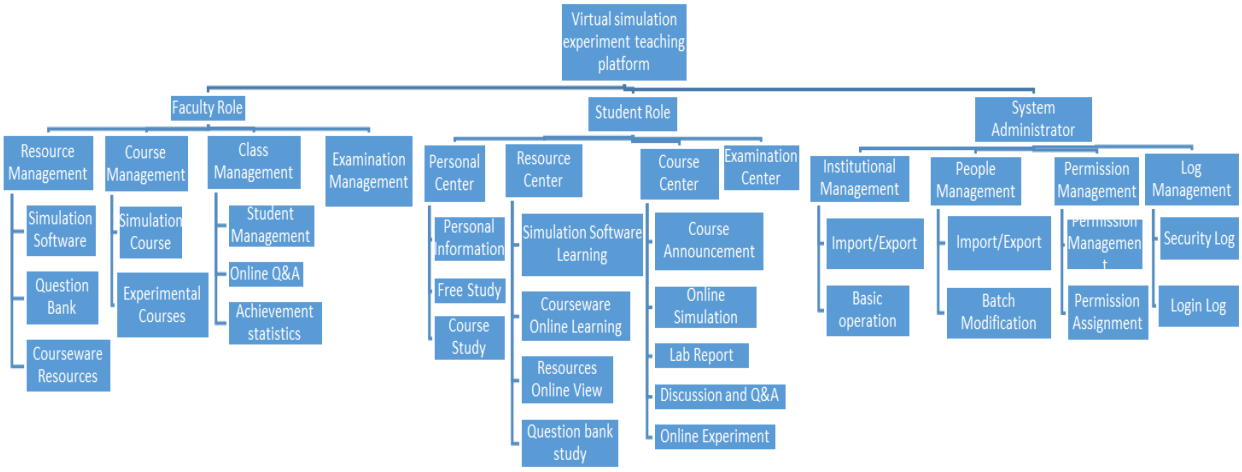

Figure 8: Organization frame diagram.

Virtual simulation software learning is the main function, its virtual simulation of the main interface is shown in Figure 9 - Figure 11, this virtual simulation of sewage treatment plant involves treatment devices including coarse grate room, fine grate room, aeration sedimentation tank, primary sedimentation tank, A2O reaction tank, secondary sedimentation tank, thickening tank, oxidation ditch, dosing room, sludge dewatering plant, etc., through the 2D and 3D display advantages of the virtual simulation system, the complete The process information is displayed to students through the 2D system, while the plant, structures, equipment and operations involved in the process are conveyed through the 3D system, so that students can walk through the entire simulation process immersively by using the mouse and keyboard at the computer. In addition, the information display bar of the system provides relevant information for detailed knowledge learning, summarization and conclusion. Through the interactive function of the virtual simulation teaching system, students can adjust the parameters of treatment flow, dosing amount and fan by adjusting switches, regulating valves and other components in the system and record the corresponding experimental results to verify the accuracy of theoretical calculations. Combining principle understanding, theoretical calculation and simulation of actual operation, repeated experimental operations can be performed during the learning process, thus deepening the understanding and knowledge of the principle and influencing factors.

Figure 9: Virtual reality system of sewage treatment plant.

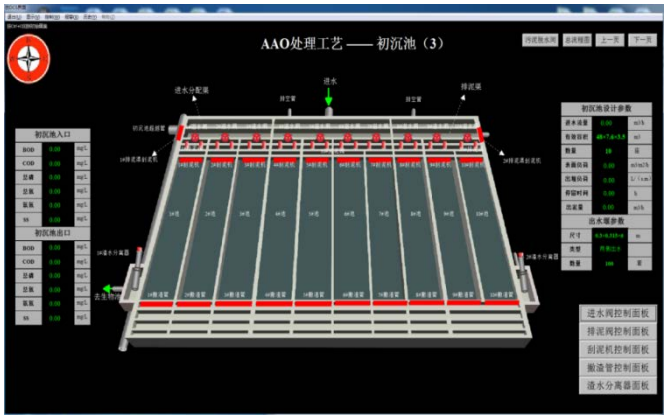

Figure 10: 2D primary sedimentation tank.

Figure 11: 3D oxidation-ditch System.

2.5 Teaching Effect

The wastewater treatment virtual simulation experimental teaching system has been applied to the teaching of pollution control engineering experiment B in the College of Environment and Resources of Fuzhou University. The system program can realize flipped teaching, student-oriented, give full play to the subjective initiative of students, using an immersive teaching environment virtual simulation in the wastewater treatment plant, students in the virtual simulation space, observe the characteristics of the treatment facility model, understand the structure and function of common treatment facilities, through the simulation of pollution treatment process, understanding the overall process and process principles, students' engineering practice ability has been further Students' engineering practice ability is further strengthened. The project adopts task-based, students' participation and interest are high, and the teaching effect is good. Moreover, through the tracking data of the virtual simulation teaching system, such as time and number of study sessions, test scores, teachers can better understand the learning situation of students and make timely adjustments to the teaching process to improve the teaching effect.

3. Conclusion

For environmental engineering majors in the field internship costs high road distance, the whole process cycle is long, can not be difficult to operate on site, change the process parameters and the

potential accident occurred by chance and other problem limitations, this paper explores the application of virtual reality virtual simulation technology to the reality of sewage treatment plant as a model to build virtual reality virtual simulation experimental teaching system for experimental teaching practice. The wastewater treatment virtual simulation experimental teaching system solves the problem of time and space limitations, and through the immersion mode of flipped education, mobilize students' learning enthusiasm, cultivate students' continuous learning ability, and improve the quality of teaching.

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