4th International Conference on Contemporary Education, Social Sciences and Humanities (ICCESSH 2019)

Construction and Research of Virtual Simulation Experiment Teaching System for Engineering Management and Engineering Cost*

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Abstract—Virtual simulation experiment teaching technology plays an important role in the field of higher education, and is an important part of informationization of undergraduate education in construction engineering management. According to the characteristics of engineering management experiment teaching, the necessity of virtual simulation experiment teaching in engineering management specialty is analyzed. Taking the construction of virtual simulation experiment teaching center for engineering management and engineering cost as an example, this paper introduces how virtual simulation experiment teaching can bring its advantages into full play in the training process of engineering management professionals in colleges and universities. This paper also analyzes the construction idea, construction content and experiment teaching characteristics of the center that Xi'an Fanyi University constructs a multilevel and modular virtual simulation experiment teaching system to serve the training of undergraduate engineering management professionals. It has provided a reference for the construction of virtual simulation experimental teaching center for engineering management specialty.

Keywords—virtual simulation; experiment teaching; engineering management; engineering cost

I. INTRODUCTION

Virtual simulation experiment teaching is an important part of higher education informatization construction and experiment teaching demonstration center construction, and is the product of the deep integration of subject specialty and information technology [1], [2]. Since 2013, a number of virtual simulation experiment teaching centers with leading and demonstrating functions have been constructed by the education sector, which continuously promotes the construction of experiment teaching informationization and the reform and innovation of experiment teaching in colleges and universities [3], [4]. Engineering management experiment is an important part of undergraduate teaching of engineering management and engineering cost specialty. It plays an important role in cultivating students' innovative spirit, practical ability and comprehensive quality. The application of virtual simulation technology in experiment teaching can break through the limitations of insufficient site, high cost, safety problems and being difficult to show the mechanism of action of engineering entity experiment, effectively assist entity experiment, and realize the sharing of teaching resources [5].

II. CONSTRAINTS IN ENTITY TEACHING AND EXPERIMENTS OF ENGINEERING MANAGEMENT AND ENGINEERING COST

Engineering management experiment is a compulsory course for students majoring in construction engineering (engineering management, engineering cost, etc.), including basic, core and comprehensive experiments. Many practical problems have been encountered in the past physical experiment teaching.

The experiment difficulty is high. Engineering structure design, life cycle management of construction projects, rebar sampling measurement, building model construction and so on are highly difficult experiments, involving many special equipment, technical difficulties and high cost of experiments. Schools often do not have the conditions to set up real experiments.

The experiment mechanism can't be demonstrated. For example, in the process of construction industrialization, the mechanism of the coupling of electronic bidding, inventory valuation and modern project management technology can't be reproduced by real experiments.

It can't keep up with the development of construction industry. Due to the limitation of funds and sites, engineering project management can't build a life cycle laboratory; the existing experimental training sites and equipment are limited; students participate in a low degree or can only participate in some demonstration experiments, which can't meet the actual needs of students to start experiments.

^{*}Fund: The project of 13th Five-year Plan of Science of Education in Shaanxi Province — "Research on the Training Mode of the Core Competitiveness of Engineering Management Professionals in Private Universities" (SGH17H483); the Key Teaching Reform Project of Xi'an Fanyi University — "Research on the Teaching Reform of Engineering Project Management Based on Virtual Simulation" (J18A04)

Engineering practice software can't be applied to experiment teaching, and much high-quality virtual experiment teaching resources can't be open and shared.

With the development of construction industrialization. more and more professionals who are skilled in modern information construction technology and project management technology are needed in the construction industry, which puts forward new standards and requirements for the experiment teaching of engineering management and engineering cost. Due to the low feasibility of many entity experiment teaching, it is not conducive to the cultivation of students' practical ability and innovative consciousness. The virtual simulation experiment teaching center aims at improving students' innovative spirit and practical ability in an all-round way, and focuses on sharing high-quality resources. It can greatly promote the construction of experiment teaching informatization and the open sharing of experiment teaching resources, and promote the teaching reform and innovation of experiment teaching in colleges and universities.

III. CONSTRUCTION OF VIRTUAL SIMULATION EXPERIMENT TEACHING PLATFORM FOR ENGINEERING MANAGEMENT AND ENGINEERING COST

In May 2012, Xi'an Fanyi University formally established the virtual simulation experiment teaching center of engineering management and engineering cost, relying on the advantages of school-enterprise cooperation and a good platform of industry-university-research cooperation. The center has made some achievements in laboratory construction, hardware and software configuration, virtual experiment teaching courseware design, virtual simulation experiment teaching team construction and so on. In 2014. the experiment center was appraised as the virtual simulation experiment teaching center of demonstration engineering in Xi'an Fanyi University. With the help of unique engineering technology advantages and the school-enterprise cooperation mechanism, the center has planned and constructed four kinds of experiment teaching resources, namely, engineering mechanics and structure experiment, construction organization design, measurement and valuation simulation, and comprehensive engineering management training. It has built four kinds of experiment platforms, namely, demonstration of architectural mechanics and structural principle, measurement and valuation simulation. simulation construction project management and comprehensive training simulation of construction engineering. The teaching features and advantages of the virtual simulation experiment of building engineering basic comprehensive experiment. virtual simulation of construction technology and management experiment, and virtual design of engineering measurement and valuation experiment have been preliminarily formed.

A. Structure of Virtual Simulation Experiment Teaching Platform

The virtual simulation experiment platform for engineering management and engineering cost provides

students with various virtual simulation, hardware-in-theloop simulation and verification, advanced virtual model design learning platforms in the construction process of combining virtual with real. It mainly undertakes the experiments of 16 courses, such as construction materials, building mechanics and structure, engineering drawing, engineering surveying, building application software, building engineering measurement and valuation, installation engineering measurement and valuation, construction organization and design, and the task of nearly 50 experiment teaching projects. It covers the whole contents of undergraduate professional basic courses, core courses, comprehensive courses and professional design courses, thus forming a relatively complete experiment teaching system. The structure design of virtual simulation experiment platform is shown in "Fig. 1".

B. Semi-simulation Platform for Engineering Materials Testing

Semi-simulation experiment platform for engineering materials is a cement test and concrete mix test using advanced technology such as virtual reality technology and three-dimensional modeling technology. With this platform, students can not only learn virtual reality technology, but also carry out repeated experiments on the hardware platform, providing a high-quality experiment operation platform for undergraduates' curriculum practice, curriculum validation and so on, in order to cultivate and improve students' practical and innovative abilities. Typical test items include cement test and concrete mix ratio test.

The semi-simulation platform for cement test is equipped with relevant physical test instruments and equipment, including four cement mortar mixers, four cement mortar vibration compacting platforms, two negative pressure sieve analyzers, four flexural test platforms, two TYE-300 pressure test platforms, one constant temperature and humidity standard curing box, two Lei's boiling boilers and so on. It supports the cement fineness test (as shown in "Fig. 2"), water consumption test of cement standard consistency, cement setting time test, cement volume stability test, cement mortar strength test. Through experiments, the compressive strength and flexural strength of cement sand at specified age are measured, and the strength grade of cement is determined or verified by comparing the strength values of cement at each standard age specified in the national standard.

The main instruments and equipment for concrete mix ratio test include: two TYE-2000 pressure test machines, one concrete mixer, one concrete shaker, four shakers, one dryer, etc. It supports aggregate test, workability test and compressive strength test of concrete. Through the experiment, the students can master the way and method of concrete mix design, and it can cultivate their abilities to analyze and solve problems. The simulation platform for concrete and workability experiments is shown in "Fig. 3". Virtual simulation experiment teaching platform for engineering management and engineering cost



Fig. 1. Structure of virtual simulation experiment teaching platform for engineering management and engineering cost.



Fig. 2. Cement fineness simulation test.



Fig. 3. Concrete and workability simulation test.

C. Semi-simulation Experiment Platform for Construction Engineering Management

The semi-simulation experiment platform of engineering management includes semi-physical sand table deduction experiment and virtual simulation experiment of engineering management. Hardware-in-the-loop physical sand table simulation experiment (as shown in "Fig. 4") simulates the environment of engineering management through hardware and software equipment, and verifies the results of numerical simulation experiment. The experiment projects are Triumph Gate Project, Century Bridge Project, China Pavilion Project, Tianjin Port Project, etc. The purpose is to simulate the whole process of engineering management of a specific project from bidding to completion by means of visual sand table deduction of engineering management. The virtual simulation experiment of engineering management uses engineering management assessment system, engineering management analysis tool software and so on. It can manage the whole life cycle of virtual project, including the design, decision-making, the construction to completion of the project, and support the undergraduate course experiment of "construction engineering management". The virtual simulation platform of engineering management covers the physical and functional characteristics of the engineering components in the whole life cycle of the project, and carries out the digital expression of the engineering management Virtual simulation experiment of project elements. management is usually a high-cost, high-risk and severely restricted experiment. Virtual project management experiment solves the problem that high-cost experiment lacks real experimental environment. At the same time, it cultivates students' construction management ability. practical ability and engineering application ability.





Fig. 4. Physical sand table simulation experiment of project management.

D. BIM Engineering Measurement and Valuation Simulation Experiment Platform

BIM Engineering Cost Software Training Platform supports the experiment teaching of 12 professional theoretical courses such as AUTOCAD and Engineering Drawing, Engineering Cost Management, Construction Engineering Measurement and Valuation, Installation Engineering Measurement and Valuation, Application of Engineering Cost Software, Engineering Quantity List Valuation Practice, Construction Practice, Cost Practice, Engineering Bidding Management, etc. Each course has about 10 hours of experiments and 20 projects. The task is about 120 hours of experiment. Typical experiment items are engineering drawing, Goldon graphic AUTOCAD calculation, Goldon steel bar calculation, Goldon installation calculation and Goldon pricing, etc. This platform allows students to master the basic methods and skills of computer graphics. Through the teaching and training of Goldon Quantitative and Valuation Software, students can use computers to compile budget documents of engineering bill and bidding documents skillfully.

The simulation experiment of engineering cost simulates the complex physical mechanism of steel bar duplication, civil engineering calculation and installation calculation in the process of engineering quantity measurement and valuation, including pile foundation engineering, main structure engineering, decoration and fitting-out engineering and roofing engineering, and can also optimize the parameters and analyze the influencing factors. The experiment platform can transform teachers' scientific research achievements into teaching courseware and guide students to construct building simulation models. It can not only study the building construction and design principles through simulation experiments, but also enable students to learn computer-aided design and simulation technology. Typical experimental projects include civil engineering measurement and valuation (as shown in "Fig. 5") and installation engineering measurement and valuation (as shown in "Fig. 6")



Fig. 5. Virtual simulation experiment of measurement and valuation of construction engineering.



Fig. 6. Virtual simulation experiment of measurement and valuation for installation engineering.

E. Integrated Training Platform for Virtual Simulation of Construction Engineering

Virtual simulation training platform of engineering adopts advanced virtual reality technology, multimedia technology and network technology, which can vividly display the design of construction organization and its working principle. The platform mainly supports the teaching tasks of basic and comprehensive engineering management experiments. It usually combines with real experiments — real experiments in class and virtual experiments outside class. At present, the platform has one set of virtual simulation integrated training platform of engineering (including six training modules and 51 simulation training terminals). The main training items are: simulation training of construction engineering (as shown in "Fig. 7"), three-dimensional visualization construction safety management training, and survey engineering simulation integrated training, municipal road and bridge engineering simulation integrated training, etc. It covers virtual observation, decomposition demonstration and virtual exercises of construction engineering. It supports several experiment projects of six courses, such as house architecture, engineering structure, construction technology, construction engineering management, construction training, construction organization and design.

The experiment platform enables students to understand the principles of building construction and design, to be familiar with the construction site technology and management process, to deepen the accurate mastery of the sequence of construction technology, to standardize operation, to be familiar with the data management and quality control of construction process, to master the responsibilities and operation norms of construction management positions, and to enhance the comprehensive application ability in technology and management.



Fig. 7. Construction process simulation training.

IV. CHARACTERISTICS AND INNOVATION OF VIRTUAL SIMULATION EXPERIMENT TEACHING CENTER FOR ENGINEERING MANAGEMENT AND ENGINEERING COST

A. Career Orientation: Serving Regional Economic Development

Guided by the school-running ideology of Xi'an Fanyi University, facing the industry and serving the local areas, adapting to the needs of production and management, an experiment teaching system is established, which conforms to the orientation of the university, reflects the characteristics of applied undergraduate courses and has a clear career orientation. In the course of experiment teaching, aiming at the problems that the real experiments of many courses are difficult to complete or do not have the real experiment conditions, such as the construction of engineering design model, the cost accounting of engineering projects, the safety management in the process of construction management and so on. Through virtual simulation, and three-dimensional animation demonstration, engineering design principle, project cost calculation, project safety management test and other experiments have been solved, realizing the combination of virtual and real, complementary advantages.

B. Independent Design: Constructing Professional Training System

Virtual simulation experiment teaching center of engineering management and engineering cost pays attention to the comprehensive application of experiment teaching resources and the development of courseware. It successively designs engineering survey training courseware, engineering project management training courseware, construction application skills training manual based on virtual simulation, engineering drawing and engineering CAD comprehensive training manual for experiment teaching. The experiment teaching resources cover the basic courses of undergraduate civil engineering materials, engineering drawing, engineering surveying, housing architecture and so on; the theoretical courses of architectural mechanics and structure, construction organization and design; the core courses of engineering management, construction engineering measurement and valuation, installation engineering measurement and valuation, and computer-aided design, which can support students' graduation design. A relatively complete experiment teaching system has been preliminarily formed, as well as the combination of virtue and reality in comprehensive experiment of building engineering foundation, pure virtual simulation of measurement and valuation experiment, virtual design of construction organization design experiment and virtual reality of construction project management experiment.

C. Integration of Industry and Education: Focusing on the Transformation of Research Results

The experiment center has signed school-enterprise cooperation agreements with many large enterprises to further explore the benign cycle model of "production, learning, research and utilization" of "technology research ---scientific research achievements — social service experiment teaching". Under the guidance of the university, the experiment center of engineering management and engineering cost will develop long-term and deep cooperation with the enterprise in many ways, such as joint development, co-construction of laboratories, complementary advantages, and so on, to form a new mode of co-construction and co-management of resources construction.

industry-university-research On the one hand, cooperation solves the research problems and improves the enterprise's efficiency for the enterprise's architectural engineering design, bidding documents compilation, list valuation and engineering structure testing; on the other hand, the research results produced by the cooperation will greatly enrich the teaching resources, transform them into teaching courseware and teaching content, and create conditions for students to carry out innovation and entrepreneurship team incubation, virtual simulation technology training, innovation and entrepreneurship project guidance and other work. The experiment center can incubate more than 10 innovative entrepreneurship teams every year. In each year, it organizes mature innovative entrepreneurship teams to declare innovative entrepreneurship projects for college, provincial and national college students. Through the support of innovative entrepreneurship projects, it promotes students to carry out in-depth research. In the past three years, more than 10 virtual simulation projects have been established by university and provincial college students' innovation and entrepreneurship projects.

The virtual simulation experiment teaching in Xi'an Fanyi University not only provides an innovative design



platform for undergraduates, but also improves teachers' information technology education level and experiment teaching ability. On the basis of combining the national competition of building software skills certification in institutions of higher education, the national BIM electronic bidding competition in institutions of higher education, the national competition of building construction application skills, and the national BIM application skills competition in institutions of higher education, the students' innovative ability and comprehensive professional quality are further trained.

V. CONCLUSION

Engineering virtual simulation experiment is an important part of the training of civil engineering related professionals. It plays an important role in training students' operational ability, practical ability and innovative spirit. With the increasingly mature application of Internet and construction information technology in the field of construction, the construction industry has put forward new requirements for engineering professionals. Newly-built undergraduate colleges and universities should actively adapt to the needs of market competition, speed up the construction of virtual simulation training platform, train compound technical and skilled personnel who can quickly master the posts. skills of construction engineering and comprehensively improve the quality of personnel training in new disciplines. The virtual simulation experiment teaching center of engineering management and engineering cost of Xi'an Fanyi University will seize the opportunities of integration of industry and education, school-enterprise cooperation and higher education "based on this", further strengthen the construction information of engineering education, undergraduate management deepen the cooperation between universities and enterprises, expand virtual simulation experiment teaching resources, improve the joint construction and sharing mechanism [6], and give full play to the construction benefits of practical resources.

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