

# Strengthen the Virtual Simulation Teaching System, Improve the Practical Teaching Level

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## ABSTRACT

Higher Education Information Technology is an important way to raise the level of education. depending on the development of the national virtual simulation experimental teaching center, a unique virtual simulation teaching system, including five integrations (the integration of theory and practice, virtualization and reality, indoor and field, teaching and research, campus and off-campus), four layers (fundamental cognition of engineering, indoor simulation, scene simulation training and production field operations), three modes (desktop virtual experiment, immersive simulation training, and experience interactive training) and multi-modules are built, considering the developmental needs of higher engineering education and our characteristics, and aiming at cultivating students' engineering practical and innovation ability. With the help of these virtual simulation tools, the invisible, inaccessible, irreversible, high-cost operations become more visual, intuitive and operational. As a result, the teaching effect and the teaching level of industry training are deeply strengthened.

## KEYWORDS

Virtual simulation; System; Mode; Training

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## 1 INTRODUCTION

The rapid development of computer and information technology has brought profound changes to experimental teaching, and made the virtual simulation technology gradually mature. Utilizing computers, the virtual simulation software and equipment, we improve the experimental training environment and strengthen the teaching efficiency, to make the invisible, inaccessible, in-converse, high-cost operations more visual, intuitive and operational. At present, we receive a large number of students, with inadequate teaching facilities and high teaching expenses. In this situation, virtual simulation technology has become a leap of educational technology, and also become a new direction of experimental teaching reform<sup>1, 2</sup>. Country pays great attention to the application of virtual simulation teaching methods. Petroleum Industry Training Centre, which belongs to China University of Petroleum, as the first batch of national virtual simulation experimental teaching center, takes the initiative to adapt to the new requirement for talents training as the rapid development of the oil industry. In addition to sharing experimental teaching resources of high quality, we focus on the construction of information technology experimental teaching resources. At the same time, we build a systematic virtual simulation teaching platform and virtual simulation teaching system to improve the standard of teaching in industrial training<sup>3</sup>.

## 2 BUILDING VIRTUAL SIMULATION TEACHING SYSTEM

### 2.1 Virtual Simulation Teaching System

The center builds a virtual simulation teaching system as Fig. 1, which includes five integrations, four layers, three modes, multi-modules. The system is based on the requirement of engineering education and oil industry characteristics. First of all, the system consists of five integrations, which mean the integration of theory and

practice, virtualization and reality, indoor and field, teaching and research, campus and off-campus. Secondly, the core area is made up of four layers, which include fundamental cognition of engineering, indoor simulation, scene simulation training and production field operations. In this system, a number of virtual simulation teaching modules are established, including mechanical manufacturing, oil and gas industry production, experimental instruments, technology innovation etc. Meanwhile, we explore and effectively implement three kinds of experimental training teaching modes, which are the desktop virtual experiment, immersive simulation training, and experience interactive training, so the practical skills of college students are strengthened.

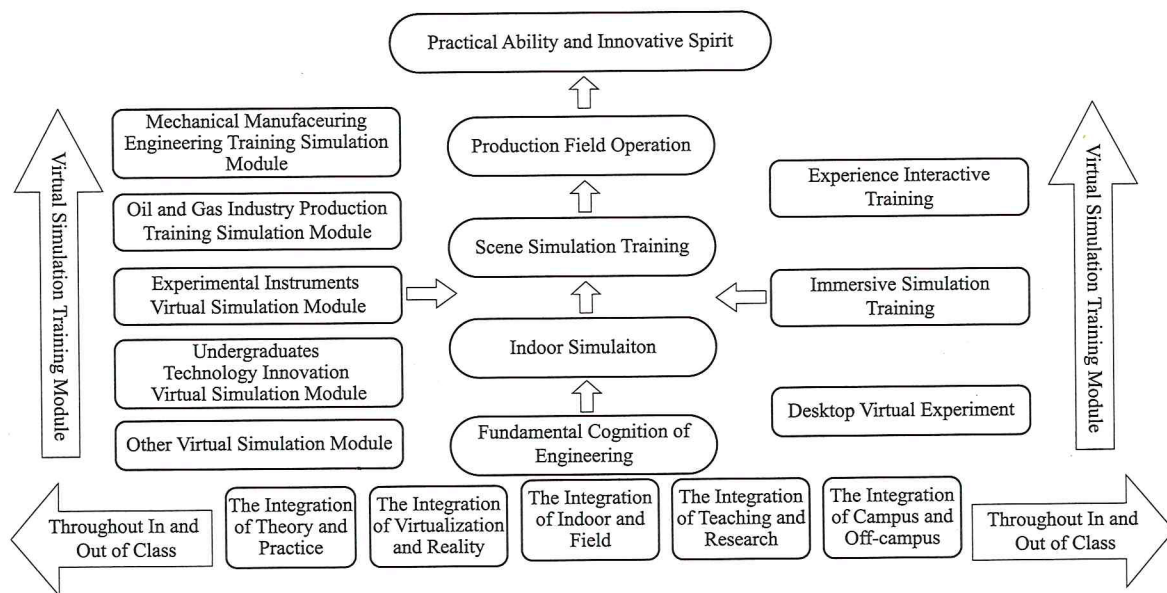


Fig. 1 Virtual simulation teaching system

## 2.2 Achieving Five Integrations as the Foundation

*The Integration of Theory and Practice:* By the virtual simulation technology, we combine specific operation processes with a lot of relevant knowledge, such as mechanical manufacturing, oil and gas production process, and build three-dimensional system and teaching courseware. Theory is used to instruct practice, and practice is used to strengthen the understanding of theory, and finally achieve the unity of theory and practice.

*The Integration of Virtualization and Reality:* In the process of virtual simulation teaching, “combination of virtualization and reality, virtualization assisting reality” is specially emphasized. During this process, virtual simulation operation and real production processes are closely integrated. Students complete the relevant operations by virtual simulation software, which simulates the actual process, equipment and procedures. We achieve a high degree of industrialization simulation, and improve teaching effectiveness.

*The Integration of Indoor and Field:* The region and production advantages of the school and training center give good condition to training. At the base of study of indoor simulation operation, students can access to field production easily. Finally the unity of indoor simulation and field operations can be achieved.

*The Integration of Teaching and Research:* The center pays attention to the combination of production, study and research. Most of research projects are from teaching practice, the simulation teaching equipment and virtual software developed adapt to the needs of teaching, and they are applied to practical teaching and innovation activities of students, the results are good.

*The Integration of Campus and Off-campus:* Teaching area includes industrial training center in the campus, practice center off-campus and practice base. With the cooperation at laboratories building, talents training, technology developing, and close communication and cooperation with companies in campus and off campus, we create good conditions to perfect virtual simulation teaching system and improve students’ practical ability.

### 2.3 Strengthening Four Layers of Teaching as the Core

*Fundamental Cognition of Engineering:* The part mainly explains oil and gas production basic knowledge, including principle and crafts of mechanical manufacturing equipment, geology, drilling, oil production, gathering and transportation, etc. It brings up the basic cognitive to students about manufacturing process, mechanical equipment and technological process, students can lay a firm foundation for future study.

*Indoor Simulation:* By means of a large number of simulation teaching equipment and virtual software, students can get a variety of operational training simulations, which include the process of machinery manufacturing, industrial processes of oil and gas development, equipment operation instruments, and technological innovation. So students can master basic practical skills.

*Scene Simulation Training:* In the scene bases or practice centers, students can use real production equipment or test wells with related simulation teaching software, and carry out industrial processes and skills practice more effectively in combination with virtual simulation and actual operation.

*Production Field Operation:* Firstly we need to be familiar with basic principle and complete virtual simulation training. And then, under the guidance of scene engineers, students carried out practice and training by real production and processing equipment or oil facilities. Finally, students are able to truly master those professional practice skills.

### 2.4 The Implementation of Three Teaching Modes as the Learning Tools

*Desktop Virtual Experiment:* We simulate related industrial process with virtual reality technology, and replace the real objects with virtual equipment, such as virtual devices, virtual wells, virtual stations, etc. Machinery manufacturing process and invisible underground scene are simulated as the three-dimensional scene of safe operation, realizing visual simulation of structure and crafts, and showing on the computer desktop. It improves learning efficiency.

*Immersive Simulation Training:* We make realistic virtual environment with multiple perception of watch, hearing and touching by the use of related technologies. Through related interactive device (operating lever, helmet, multimedia devices, etc.), we simulate each procedure in the virtual scene, and do immersive, interactive, visual simulation and information exchange. It makes training be closer to real scenarios.

*Experience Interactive Training:* By hybrid architecture of physical simulation equipment and operating software, we make instrumentation, oil and gas production equipment in a certain percentage, which have similar structures and functions to real objects. Students operate the software and simulate the system control themselves. The simulation can do effective real interaction and be used for repeated training among the operator, simulation equipment and experimental system. So the practical ability can be improved.

### 2.5 The Virtual Simulation Teaching Module as System Support

In recent years, the training center has bought or domestically developed many equipment and software about virtual simulation teaching, and built more virtual simulation practice teaching modules. These teaching modules come down to mechanical manufacture, oil and gas industry production, experimental instruments development, technology innovation and so on. It is based on highly interactive virtual real system, and can meet the demand of students about practice teaching with three modes.

*Mechanical Manufacturing Engineering Training Simulation Module:* Combining with the requirements of basic types of mechanical manufacturing, the center has purchased and produced a lot of courseware and software, analyzed the structures, principles, features of related machinery and equipment, showed the machinery manufacturing process vividly. NC simulation teaching software can simulate the operation of NC lathe machine, NC milling machine and machining center, forming a living and operable NC machining training textbook<sup>4</sup>, which

has been widely used in practical training and vocational skills training. Combining computer technology with welding scene simulation engine, the virtual welding equipment system can simulate various welding methods comprehensively, the quality of learning is improved and the cost of teaching is reduced. Virtual product assembling and disassembling in interactive virtual assembling environment plays a unique role in new product development and operational training. Some training of unconventional machining and rapid prototyping technology conducting in the simulation control room improve the quality of learning.

*Oil and Gas industry Production Training Simulation Module:* Based on the characteristics of industry, virtual reality and multimedia technologies, teachers and technologists in the center simulate each real production aspects of the petroleum industry, particularly involving high-dangerous or extreme environments, inaccessible or irreversible high risk, high-cost and large or comprehensive training, and allow the system to achieve modeling, role-based, event-based, this greatly improves the teaching and training effect. Currently, the center has developed more than 30 modules and over 200 hours of virtual simulation software used in daily teaching, these modules and simulation software covered oil and gas geology, drilling, logging, cementing, oil production, underground operations, oil and gas gathering, processing, exercise of emergency pre-plans and other fields. According to the characteristics of the various professional fields, students can use a combining method of different modes based on the teaching requirements to achieve training objectives.

*Experimental Instruments Virtual Simulation Module:* In recent years, for the application demands of new technology for oil and gas exploration and petrochemicals in petrochemical industry, the center continued to strengthen the application of the virtual simulation technology in experiment equipment and construct virtual instrument testing platform. In practice, students can use common hardware platform and the software of virtual simulation technology for reservoir flooding and origin of oil and gas to build experimental equipment process, design and construct their own instrumentation system and complete relative simulation experiment and training. Simultaneously, at the beginning of new technologies and materials' production, we can find out the best program to guide the application of field production through the validation of subsurface environment and refine process's virtual simulation, those new technologies and new materials indoors. The intelligence and virtualization of instruments have become a direction for the future of laboratory and research institutions. The idea that "The Soft is Instruments" has gradually being accepted.

*Undergraduates Technology Innovation Virtual Simulation Module:* Depending on technical advantages and simulation teaching equipment, the center can provide corresponding technology and device platforms for students. The center uses projects, research, and technology competitions as the main content to attract different faculty students which have professional ability and strong sense of innovation to participate in the study on virtual simulation innovation activities. With the virtual simulation technology, the center can provide students with all types of modules, elements and devices to set up the experimental procedures of relevant mechanical equipments or oilfield development & production, and carry out scientific and technological innovation. It will play positive effect in cultivating the ability of innovation and comprehensive quality of students.

### 3 THE EFFECTIVENESS OF VIRTUAL SIMULATION TRAINING TEACHING

*Making Invisible, Inaccessible Work Scene Visualized:* Virtual simulation training project can simulate thermal processing, complex parts processing, the flowing of oil-gas-water in pipelines and the migration of hydrocarbon under several kilometers. Virtual simulation training project through virtual simulation technology makes the invisible, inaccessible scene of machining and oil production no longer subject to time and space constraints, and vividly presented in front of everyone. Then the learning motivation and efficiency of students are improved.

*Making Uncontrollable and Irreversible Scene Repeated and Representation:* Petroleum geological structure is long gradually evolved, which belongs to the uncontrolled and irreversible process. Some mechanical manufacturing process is difficult to replicate. Training programs relate to experiments simulate earthquakes, volcanic eruption, plate collision, geomorphic evolution process and some mechanical manufacturing process through virtual simulation technology. So students can experience intuitively and improve learning effect.

*Making High-risk and High-pollution Operations Safe and Environmental Friendly:* In the process of oil exploration and development, many construction jobs are high-risk, such as drilling, blowout during well repairing process, ultra-high pressure liquid leakage during the acidification fracturing operation. Relevant experimental training program teaching through virtual simulation technology can avoid the danger of blowout and ultra-high pressure liquid leakage. All the problems are in a virtual environment, and it will have no any impact on the real environment and personal safety, so it can achieve safe and environmental-friendly effect.

*Making High-cost and High-consumption Works Economical:* The cost of petroleum development is very high, a well costs tens of millions CNY, so it belongs to typical area of high cost and high consumption. The CNC machine tools, machining centers and laser equipment also cost several millions CNY, and the more students the higher cost. Using virtual simulation technology to build virtual environments and virtual appliances can reduce the training costs and improve the training effect. Students attain basically identical experience of operating the real equipment through the application of virtual software and simulation equipment.

*Making Industrial Scene, Complex Operation Situation Scalable:* In the industrial production process, there are many big projects, such as drilling site occupying more than a dozen acres of land, the refinery station including thousands of equipment, some oil and gas pipelines extending thousands of kilometers. Students get only local understanding in production field study. Operation scene can be directly established in a virtual environment through virtual simulation project. Students can learn the entire production from the macro scene, learn the positional relationship and interaction of each unit and go deep into each unit to carry on detailed study.

#### 4 CONCLUSIONS

The rapid development of virtual technology provides us a new direction for modern experimental teaching reform. We get a new idea of teaching for modern experiments with learning and exploring actively. In the near future, experimental teaching based on the virtual technology will be used widely. Virtual simulation teaching system will have a profound impact on improving the teaching level, optimizing the teaching process, improving the experimental environment, enhancing ability test, and culturing the innovation awareness capacity.

#### REFERENCES

1. WeiGuo Cai. Application of virtual simulation technology in mechanical engineering experimental teaching [J]. *Experimental Technology and Management*, 2011 (8): 76-79.
2. Gengyan Xiang, et al. Development of virtual experiment in teaching practice [J]. *Computer Education*, 2014 (24): 119-121.
3. Qihong Feng, et al. Construction of experimental teaching center of virtual simulation for petroleum exploration and development industry [J]. *Experimental Technology and Management*, 2014 (9): 1-4.
4. Shangjin Li. Application of virtual reality technology in practice teaching of CNC technology [J]. *Silicon Valley*, 2008 (9): 77.