Open Access Library Journal
2022, Volume 9, e8930
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Application of Virtual Simulation Experiments in Teaching Chemical Engineering Practical Courses

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How to cite this paper: Wang, J., Yang, K. and Zhu, C.S. (2022) Application of Virtual Simulation Experiments in Teaching Chemical Engineering Practical Courses. *Open Access Library Journal*, **9**: e8930.
https://doi.org/10.4236/oalib.1108930

Received: May 25, 2022
Accepted: June 10, 2022
Published: June 14, 2022

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Abstract

In order to overcome the limitations in chemical practical teaching in colleges and universities, virtual simulation teaching is rapidly developed as a modern teaching measure combining theory and simulation practice, which can effectively solve the teaching limitations of chemical engineering practice in colleges and universities. In this paper, the development of virtual simulation practical teaching is reviewed, and the reform and practice of teaching mode and the shortcomings and improvement measures are discussed. A series of novel virtual simulation experiments were introduced in our college to enhance the professional comprehensive quality of chemical engineering students.

Subject Areas

Higher Education, Teaching and Learning Technologies

Keywords

Virtual Simulation, Chemical Engineering, Practical Teaching

1. Introduction

As an essential part of chemical engineering courses, chemical engineering practice plays a role as a bridge for students to step from school to society, but the practical courses of chemical engineering major in universities have always been relatively weak [1]. At the end of the 20th century, William Wolf, an American scholar, first proposed the concept of the virtual laboratory. With the rapid development of networks and technology, virtual simulation technology is gradu-

ally mature and applied to class teaching, integrated with teaching content to create a high-quality teaching environment [2]. The state strongly supports and promotes the construction of virtual prevention teaching experiment projects. In July 2017, the Ministry of Education issued the Notice of The General Office of the Ministry of Education on the Construction of Demonstration Virtual Simulation Experimental Teaching Project in 2017-2020. For the purpose of encouraging universities to actively carry out construction of virtual simulation experimental teaching project, the government increases the funding rapidly. With the advent of the ERA of 5G high-speed network, the development of virtual simulation courses has also seen a leap forward, especially in the case of the outbreak of the COVID-19 pandemic in 2020, when colleges and universities are unable to open offline teaching, virtual simulation teaching is greatly favored by colleges and universities.

Although many papers before have discussed the greatly meaningful importance of VR experiments, these studies still stay in the theoretical research stage. This paper will focus on the status quo of virtual simulation practice teaching, the reform and practice of teaching mode, and the shortcomings and improvement measures.

2. Existing Problems in Virtual Simulation Practice Teaching

2.1. Lack of Authenticity

Although virtual simulation practice can achieve a high degree of restoration of the phenomena and results in the process of real experience, it is still insufficient for students' feelings in operation, such as sight, hearing, smelling and touch [3].

2.2. Poor Compatibility

At present the virtual simulation experiments of colleges and universities are struggling with each other on the construction road, with the help of superiority of their own school. However, no uniform standards have been formed, which will lead to poor compatibility, difficult secondary development. There are obstacles in connecting such projects. At present, unified resource development and open and unified standards are widely expected by universities [4].

2.3. Weak Sharing Mechanism

Under the national vigorously promote and support, the universities' projects quantity of virtual simulation experiments are growing fast, but mostly projects are purchased from outside market, independent research and development projects are not enough. Once, the virtual simulation experimental software of other companies or social institutions is purchased, many other colleges and universities will introduce the same experimental software in the case of not timely information interaction and lack of sharing mechanism, resulting in a waste of resources and lack of innovation, which cannot meet the situation of the university and give play to its unique advantages.

3. Advantages of Virtual Simulation Experiment Teaching in Chemical Practice

3.1. To Overcome the Difficulties of Many Dangerous Factors in On-Site Chemical Practical Teaching

In the practice teaching of chemical engineering under traditional teaching mode, it is a common phenomenon in domestic colleges and universities that one or two teachers take a group of dozens of students to practice learning. When the number of students is far greater than the number of teachers, the risk factor will undoubtedly increase greatly. In extreme operating environment such as high temperature and pressure, or high-risk, pollution, explosion environments, students' careless omission or mistake operation behavior could trigger a machine failure phenomenon, even cause irreversible damages to the machine, worstly cause fire or other factory accidents, ultimately cause huge economic losses and life deaths. Therefore, when domestic universities arrange chemical practice, most of the students mainly observe and seldom carry out practical operation, which directly leads to the weak safety awareness of students in chemical practice, and the serious lack of ability to deal with emergency events.

However, in our intelligent factory virtual experiment project, students can manipulate virtual characters to tour the whole factory and even operate equipment to control production. Students can have an immersive tour of modern factories without worrying about whether or not the enterprise is willing to receive them and when to arrange the tour.

3.2. To Improve Teaching Methods

Virtual simulation practice teaching changes the traditional mode of teaching practice, into the factory face to face with equipment to equipment through the computer simulation of reality into the virtual simulation software, the complete process flow and equipment manufacture as a dynamic 3D model, achieve high degree reduction of real effect of the experimental phenomena, the experimental results, the equipment composition. The visual independent computer operation of students has largely solved the phenomenon of listening more and moving less in traditional teaching.

3.3. To Lower Practical Teaching Costs

Based on the principle of letting students experience the equipment as much as possible to deepen their impression, traditional practical teaching will build chemical training bases in school, purchase equipment, and cooperate with several factories outside school to increase school resources for students' practice [5]. Considering the expenses such as car rental, accommodation arrangement and corporate guidance fees, the simulation practice teaching only needs one computer per person, which allows students to access the simulation practice project and greatly reduces the teaching cost. For example, in the virtual experiment of NMR, students can repeat the testing process of samples for infinite

times without worrying about the loss of reagents and drugs, or the aging of equipment.

4. Teaching Reform and Practice in Our College

Virtual simulation practice teaching changes the traditional teaching practice mode of directly facing the equipment in the factory, and makes dynamic 3D equipment and process model through computer simulation of technological process and equipment, so as to restore the real experimental phenomenon, experimental results and equipment composition effect to a high degree. Students visual independent computer operating much solves the problem of listening more than moving in the traditional teaching, the teacher's work has a huge change, don't need many teachers focus on students' behavior, don't need to occupy large space, to both teachers and factory at the same time to avoid the unnecessary waste of resources, low cost of practice teaching [6].

In the traditional practical teaching of chemical engineering, the number of students is far greater than the number of equipment, and some students cannot even operate independently in the limited time. In the virtual simulation experiment course, each student can use a computer to operate his own experiment, and complete the whole operation independently to get his own score. Secondly, virtual simulation experiments can be connected at anytime and anywhere, and the variety is much larger than the school physical equipment, which not only strengthens students' grasp of theoretical knowledge, but also improves their practical operation level, and broadens their horizons and insights. Mix of teaching method to let the students in practice for physical equipment, able to have enough conditions to do preview theory knowledge, safety knowledge, operational matters and autonomous simulation field inspection, more let the student independent analysis abnormal phenomena in experiment and accident problem, let the students from passive to active experiments.

The application of virtual simulation experiments teaching in chemical engineering practical courses in our college has jointly developed a series of virtual simulation software such as 3D simulation system for laboratory safety management and accident treatment, 3D simulation system for operation and maintenance of nuclear magnetic resonance spectrometer, etc. Taking the simulation software of chemical laboratory safety management and accident handling as an example, the software is divided into learning mode and assessment mode. There are 19 safety items in total, including personal protection, laboratory familiarity, fire escape, reagent spilling, and reagent contamination with clothes, poisoning prevention and electric shock safety and other practice items. To give students an immersive feeling, in order to help students deepen their memory, memorize the operation steps, increase their own laboratory safety awareness and standard operation.

Virtual reality, its principle is to make use of the powerful computing ability of modern computers to simulate the real system through Virtual computing

and construction of Virtual simulation system. After the system runs, the relevant data results can be obtained through pre-set program operation. Take the DCS Oriental virtual simulation software (hereinafter referred to as the software) installed by Zhoukou Normal University to purchase VR equipment as an example. Between the two positioning devices, students wear VR equipment and stand, and their vision will enter the chemical plant simulated by 3D simulation technology. In the simulation factory, students use two wireless controllers to control the movement of virtual characters, turning their bodies to change the direction of their vision. The equipment is connected to the electronic LCD screen, and the students' field of vision in the software is displayed on the screen with 2D animation. The trained teacher will introduce the characteristics of the process equipment in the students' field of vision. Students can have a deeper understanding of the equipment and process by virtue of the close observation of the equipment and the teacher's explanation. VR virtual simulation experiments applied to the practice of chemical engineering students is a platform for students to improve themselves.

Also we purchased Hangzhou Baizijian Deskpant modular chemical plant series products, which is an intelligent splicing electromechanical integration product. By combining the new generation of high-precision dynamic process simulation technology, the process production process of real factories can be vividly restored on the desktop. This product can build distillation series and reaction series processes, which is not only closely combined with teaching, but also dynamically illuminate basic chemical knowledge points. The software has the characteristics of building blocks, tablet computer interaction and software linkage trigger. The device can display the chemical device in miniature and flexibly build the combined process unit. The building blocks have built-in chips connected by telephone lines. After assembly, the dynamic process data will be generated after the power supply is connected. After connect with computer, automatically get blocks connection state, rendering topology frame, and build the wizard software, can guide students to complete learning content, simulation engine blocks built-in high precision technology, real time dynamic data to provide computer device, block device of the valve opening can be manually adjusted, at the same time on the computer side can do real time observation data linkage change process.

With the help of the above virtual simulation experiment project, students' practical ability and innovation consciousness are greatly encouraged. In recent years, more than 40 students have participated in the provincial College Students innovation and entrepreneurship Competition and won many awards including the first prize. Meanwhile they repeatly won the second prize in the national chemical design competition for college students since 2019.

5. Conclusion

Over the past few years, under the background of new engineering construction, we seized the development opportunity and gained one provincial first-level

virtual project, one virtual simulation first-class provincial-level course, together with two school-level virtual simulation teaching projects. Relying on the construction of the project, the virtual simulation teaching in the teaching of hardware conditions has been greatly improved. We believe that in the future with the popularity of 5G application for virtual simulation teaching projects with a qualitative leap and a bright future, under the guidance of the competent department of education, as the resources integration, set up a shared virtual simulation platform for the domestic chemical industry-university students' scientific research using open sharing, chemical virtual simulation practice will become more mature, for the progress and development of chemical major to provide significant help, The quality of students' practice teaching will be greatly improved.

Acknowledgements

This study is supported by Henan Higher Education teaching reform research and practice project (2021SJGLX521), The Ministry of Education Industry-University Cooperative Education Program (202101021019, 202102028049), and the Education reform research project of Zhoukou Normal University (J2021006).

Conflicts of Interest

The authors declare no conflicts of interest.

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