Application of Virtual Simulation and Computer Technology in Experiment and Practical Teaching

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Abstract

In the current experimental teaching and practical teaching process, there are many problems. The complex structure makes it difficult for students to understand its structure and working principle, and which is not conducive to cultivating applied students of a new era. And so on. These problems make the experiment deviate from the real sense of the experiment, are not conducive to cultivating applied students of the new era. The development of Virtual reality technology, three-dimensional modeling technology, network technology, computer technology and other technology makes it possible for the scene virtual, the process of virtual, the results reproduce. This paper studies the successful application of virtual simulation technology in experimental and practical teaching process. Also the new research direction has been mentioned in this paper, and which can specify the direction for the experimental teaching workers. The new research results provide additional technical support and guarantee for qualified college students training.

Key words: Virtual simulation, Virtual Reality Technology, Experimental teaching, practical teaching, computer technology, college students training, Internet of Objects

1. INTRODUCTION

It is shown that the best method and purpose of learning are to mobilize students' learning initiative and to highly play the students' subjective initiative, which has been proven by the principle of psychology[1]. Most students lack interest in theoretical learning in teaching materials. But practice teaching process can fully mobilize the enthusiasm of students, participation in consciousness and performance awareness. Experiments are the best means of test the theory, and the theory is the best basis for guiding the experiment. Experimental teaching make students more vividly grasp the original boring theoretical knowledge, and it exercises the students' ability and creativity. Also, it maximizes the excitement of students' interest in learning. Therefore, attention to experimental teaching is the key to stimulate students' interest in learning.

However, practical teaching is seldom taken seriously, and too much emphasis on theoretical knowledge. At present, there are many problems in the process of experimental and practical teaching in Chinese universities. Those are as follows.

- **The contradictions between less equipment and more students**: The number of sets of laboratory equipment is too small, but the number of students with the expansion of college enrollment has grown more and more. In the experimental teaching, many students are divided into a group, each group can only individual students hands-on experiment, other students can only watch or guide, cannot personally experiment. It is deviating from the original intention of the experiment. Some expensive experimental equipment does not allow students to operate. The experiment became the teacher's operation demonstration experiment completely, and students can only watch it. This did not achieve the original purpose of the experiment. It is must be understood that experimental teaching is to develop students with practical ability, observation, problem-solving ability and innovation ability. Without the students hands-on experiment, it is empty talk to develop students' practical ability.

- **The Contradiction between Network Teaching and Field Experiment**: At present, the rise of many online courses caused the contradiction between the theory and practice (Valerie, 2016; Srikanth, 2017). Network course teaching has its unique advantages in theory, but the experiments involved cannot be completed. At present, China's online curriculum teaching development like blowout, such as the development of MOOCs teaching, so it makes the possibility that cross-university teaching and learning. Students in Beijing can choose a course from a university in Nanjing. Currently, “University of China MOOCs” and “Good University Online” are the two China's most famous network teaching platforms. There are 121 universities joined the Chinese University MOOCs teaching platform currently. There are also hundreds of universities joined the Good University Online teaching platform. Network teaching platform was getting the mushrooming development. The network teaching platform allows students to learn not subject to time and space constraints. This also exacerbates the contradiction between the theory of the online course and practice or the experiment.
The contradictions of depriving students’ creating abilities and innovating abilities: It is difficult for students to find problems during experiments without hands-on operation, and it is difficult for problems or innovative ideas being verified. So the current university experiments or practice were deprived the students of the creative talent.

The contradictions of theoretical knowledge and new products cannot be synchronized: It is often being referred that introduce the new research results into teaching, expand students’ knowledge, cultivate the knowledge of the times, to meet the social application talents. But the latest research results are difficult to introduce into the classroom. The structure of new equipment with technology is complex. Students have not seen such a device before, new products in the eyes of students liking a black box. The complex structure makes it difficult for students to understand its structure and working principle, and which is not conducive to cultivating applied students of a new era.

There are still some other contradictions. For some experiments, the extremely dangerous experiment site is difficult to reach, such as high-pressure test of equipment, performance measurement of hazardous radioactive material and so on.

To carry out virtual simulation experiments or practice is the requirements of social development, but also the Chinese universities make the new initiatives on the innovative talent training methods. Virtual simulation experiment teaching is an important content of informationization construction of higher education, which is the product of deep integration of subject specialty and information technology. In August 2013, the Chinese Ministry of Education issued the “work notice on the national virtual simulation experimental teaching center construction”. This announcement marks the beginning of China's construction of virtual simulation laboratory into a large-scale, systematic, standardized and sustainable development stage (XU, 2014). The Ministry of Education has issued a document in 2013, 2014 and 2015, called for the construction of national virtual simulation experiment teaching center. As of June 2016, 300 national virtual simulation experimental teaching centers have been built. Virtual simulation experiment teaching is the embodiment of educational informationization in experimental teaching. The virtual simulation experiment is closely integrated with the professional experiment, which provides an important supplement for the experimental teaching (SUN, 2016).

From this year (2017), as the main body of college students are 21st century newborns. Their common characteristics are that they affected by new media, the internet, smart phones and so on, and various channels to access to resources, large amount of information, thinking diversity (LIU, 2017). They attach great importance to themselves and demand self-development. They are characterized by strong independent, high level of information, to be quick to accept the new things. They can be self-learning and exploration through the network. Virtual simulation experiment teaching is suitable for college students’ learning behavior and cognitive characteristics. This also demonstrates that virtual simulation experiments in China have great potential demand and market.

In the field of experimental teaching launched a major change, with interactive virtual experiment, immersion experiment, remote collaborative experiment, 3D virtual experiment and other means (ZHANG, 2016). Using information technology means, many of the top foreign colleges and universities have joined the virtual laboratory based on the practice of teaching content been in the network of open curriculum resources. In general, foreign universities in the virtual simulation experiment started earlier than China. The degree is higher than China.

2. THE DEVELOPMENT OF NEW TECHNOLOGY PROVIDES TECHNICAL SUPPORT FOR VIRTUAL SIMULATION EXPERIMENTS

2.1. The development of three-dimensional modeling software

The development of three-dimensional modeling software and computer hardware, makes the virtual simulation experiment construction have software and hardware technical support. Currently used for three-dimensional modeling software mainly are 3ds Max, UG, Pro/E, SolidWorks, CATIA, Inventor, Tribon and CAD. Each software has its own characteristics and good at, and three-dimensional modeling production is often used in conjunction with several software. On the characteristics of the software, it can be easily retrieved in the web search engine. This article is not too much here to introduce.

2.2. Virtual Reality technology

Virtual reality technology is the use of computer simulation technology, presented in front of the user in a virtual environment, and can truly reflect the changes in the operation of the object.

The virtual simulation experiment helps to evaluate the students’ experimental ability objectively (Guo, 2017). Virtual simulation experiment system is a platform based on the Internet. Equipment, laboratory content, teacher’s guidance, student operation and experimental data processing been organic integration through computer-aided, to create an operable experimental textbook.
2.3. The development of Analysis software and virtual simulation technology

As described in 2.2 of this article, virtual simulation experiment is to show a simulated environment in front of the experimenter, and to be able to truly reflect the changes in the operation of the object. Therefore, the virtual simulation experiment is not a simple playing video, there must be dynamic tracking changes in the operation of the object process. If the load is applied to a part, the stress will change synchronously, and the virtual simulation experiment will show the process of this change. At present, analysis software have finite element analysis software ANSYS, fluid analysis software Fluent, virtual simulation software Mutium, VR-Platform, UDK, unity3d and other software, powerful, stretched ability is their common characteristics. The experimental training software developed by Unity3D can be run directly through the webpage(GUO, 2016), a true one-website solution, especially for post training and distance education.

The concept of virtual laboratory was put forward in 1989 by William Wolf of the University of Virginia. It is the third design methods and forms besides theory and experiment(Li,2014). Experimenters can simulate the real environment, complete the various scheduled experiment projects, can obtain the visual effect of true, show equipment structure or principle of the traditional experiment, and rapid response to experimental teaching needs.

The characteristics of virtual laboratory are as follows(YU,2013): 1)Innovation; 2)simulation; 3)open; 4)hyperspace and 5)Operability.

Virtual simulation experiments can also be easy to show the microscopic state which is sometimes difficult to show in the traditional experiment. Such as fluid simulation experiments can study the performance of particle motion. The virtual simulation experiment breaks through the boundaries of the original curriculum experiment(QI,2013). It has increased the curious, comprehensive and innovative experiments, to strengthen the application of modern experimental methods and experimental means. It presents representative, enlightening questions, deepening students' understanding of the experiment, and it stimulates students' innovative thinking and interest.

2.4. Network technology, especially Wi-Fi

The development of network technology makes the experimental teaching resources easy to achieve sharing and dissemination, especially Wi-Fi technology progress. Wi-Fi is a technology that allows electronic devices to log into a wireless local area network (WLAN). Almost all smartphones, tablets and laptops support Wi-Fi Internet access, and which is the most widely used today as a wireless network transmission technology. In areas with Wi-Fi wireless signals, mobile phone can online without through the Unicom's Internet, and eliminating the traffic costs . Users use the network for network experiments or learning can be carried out free of charge, it also facilitates the development of virtual simulation experiments.

2.5. The technology of internet of Objects is the successful guarantee of network experiments

Internet of Objects technology is to connect any items with the Internet according to the agreed protocol, through information sensing equipment with the radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners and so on. Internet of Objects technology is a network technology for information exchange and communication to realize intelligent identification, location, tracking, monitoring and management.

The core and foundation of "Internet of Objects" is still "Internet technology", and is a network technology based on the Internet technology extension and expansion. Its client extension and was extended to any items and items to exchange information and communication.

Internet of Objects(IOO, some call it Internet of Things, IOT) technology makes the experimental equipment can be remote experiments. Of course, experiments of Internet of Objects have a rigorous system and process, and which is a new direction of research and explore. Some of the system and process as follows: the using state of equipment to determine, apply for the intervention of the experimental approval, the application of the person's qualification examination, experimental safety test results to track and judge and so on. This technology is the recent hot technology of Internet of Experimental Objects(IOEO), which has attracted the interest and concern of many instructors and scientists.

In short, the application of new technology can also save costs, free from time and space constraints, and which is the inherent motivation of the development of virtual simulation experiment. The use of virtual simulation technology can make the theoretical knowledge in textbooks effectively associated with the actual operation, so that the theoretical knowledge is no longer rigidly adhere to the books . Theory to serve the practice and strengthen the students hands-on ability also let them have a deeper understanding of the theoretical knowledge and impression.

Teaching form changes from theory to practice and theory teaching complement each other. Virtual simulation experiment to overcome the online education and online courses lack of experimental links, and the students lack of practical ability(WANG,2015). Some universities have been increasing the virtual laboratory based on the practice of teaching content in some of their open online courses.
Virtual simulation experiments also enable students to change from a single consumer to a creator and designer of a course. The future laboratory will remain a new field of research, and many studies may subvert the traditional sense of laboratory. The future laboratory is characterized by integration of innovative educational philosophy, advanced science and technology, psychology, communication, ergonomics and space construction theory, and it focus on a high degree of interaction, openness, inspiration and natural, flexible, safe and efficient human design.

3. PROBLEM SOLVING AND SUCCESSFUL APPLICATION

At present, the use of the aforementioned new technology, developed a number of virtual simulation experiments.

![Figure 1. Virtual laboratory project construction block diagram](image)

With the deepening of experimental teaching reform, the number of experimental projects will gradually increase. Together the several prominent aspects of the successful application are as the follows.

3.1. Internal structure displays and equipment virtual disassembly

Reducer is widely used in mechanical equipment, and which is the main basic project of mechanical design (WANG, 2012). In order to figure out the working principle, structure and function of the gear unit were dismantling and observed of the reducer. Physical disassembly experiments are not only costly, but also for the work of the interference, stress and movement cannot be quantitative analysis and testing. So the reducer virtual assembly experiment was used to solve this problem. As shown in Fig 2.
3.2. **Experimental study on mechanical behavior and force of four-bar mechanism based on ADAMS**

ADAMS (automatic dynamic analysis of mechanical systems) is the mechanical system dynamics automation analysis software. It is a set of virtual simulation software developed by the US mechanical power company, with high precision, fast calculation and so on. It not only can reflect the characteristics of the mechanism movement, but also can reflect the mechanism dynamic characteristics. Adams analysis principle is based on degrees of freedom (DOF) to determine the type of analysis.

- When DOF <0, it belongs to the statically problem, ADAMS cannot solve.
- When DOF = 0, only consider the system motion of the kinematic analysis of the mechanism, regardless of the movement of the external force. In the kinematic analysis, when the motion state of some members is determined, the displacement, velocity and acceleration of the remaining components are not determined according to Newton's law, but are determined by the constraint relationship between the components in the mechanism, and it is solved by the displacement algebraic equation with the linear algebraic equation of velocity and acceleration.
- When DOF> 0, Perform a kinetic analysis on the mechanism.

Adams is able to give real-time changes. This is the highlight of the virtual simulation experiment. Through the ADAMS virtual simulation experiment, it can be dynamic understanding of the four-bar linkage motion characteristics and dynamic characteristics by changing the four-link rod and other parameters, which increase the desire and initiative to understand the performance of the four-bar institutions. As is shown in Fig 3. It’s a multi-body Simulation system based on Adams.

3.3. **Test of belt drive performance**

The belt drive is widely used in mechanical transmissions and is one of the basic experiments in the mechanical design course(CAI,2011). The belt drive experiment is to let the students observe the elastic sliding and slipping phenomena of the belt drive, analyze the carrying capacity, measure and draw the elastic sliding curve and transmission efficiency curve of the belt drive. The Fig. 4 is the panel of virtual belt drive performance parameter test. The Fig. 5 is a result of virtual belt drive performance parameter test.
At present, there is a better domestic transmission performance test, fully virtualized, in the system can be easily virtual loading, and easy to simulate the results from the drive performance test.

3.4. Virtual machining experiment

CNC machining technology is one of the core technologies of modern manufacturing[24]. Modern CNC machining technology is integrated application of mechanical processing technology and microelectronics technology, represents the direction of development of mechanical engineering, and been taken as the core content of professional courses in many engineering colleges and universities of machinery manufacturing and automation profession. The teaching and training of the control technology are inseparable from the numerical control machine, but the number of machine tools used in the teaching experiment is seriously insufficient, and an accident once occurred in traditional operation experiment. In the traditional machining experiment, the
In order to allow more students to participate in the process of processing practice, our university purchased a CNC machine tool processing system "VNUC". VNUC machine tool simulation processing system was assessed by the Chinese Ministry of Labor and Social Security, and it is the most authoritative CNC machining simulation software. The VNUC virtual machining system contains a variety of CNC and different machine tools. It can change the machine type by selecting "Select Machine and System" under the Options menu. There are 3 types of machine tools available: CNC machine, CNC milling, CNC machining center. Fig. 7 is CNC milling machine of VNUC simulation system. Fig. 8 is a CNC lathes of VNUC simulation system.

![Figure 7. VNUC simulation CNC milling machine](image1)

![Figure 8. VNUC simulation CNC lathes](image2)

3.5. Virtual simulation of material mechanics

Due to security issues and the limitations of experimental funds, some experiments are difficult to achieve and other reasons. It is impossible for students to do too much material mechanical experiment. The virtual simulation experiment has been described earlier is a good solution. It can also solve the problem which is difficult to solve in the traditional experiment, such as any position of the stress measurement. Virtual experiments can also be repeated, and there is no limit.

At present, some universities have developed a virtual simulation experiment system of material mechanics, but these systems are mainly through animation or video(Li,2016). Material mechanics are the quantitative relationship between the external force and the internal force, the stress and the deformation of the bar. The qualitative demonstration of the animation is not suitable for the study of material mechanics. Accurate quantitative demonstration of experimental phenomena, on the one hand the need for complex background operations, especially need to calculate the internal force, displacement and other mechanical quantities real
time in the experimental process of constant changes in the load; the other hand, the foreground needs as simple
and clear interface as possible and easy to operate.

The principle of changes in the relationship between internal forces, displacement changes and the load:

- Axial stretching or compression: \( \varepsilon = \frac{\Delta l}{l} \)  
- Stress: \( \sigma = \frac{N}{A} \)  
- Stress when the shaft is twisted: \( \tau_{max} = \frac{T}{J_p} = \frac{T}{W_I} \)

Deflection Quadratic Differential Equation of Beam: \( EI \frac{d^2y(x)}{dx^2} = -M(x) \)

The virtual simulation software is not an animated demonstration experiment, but is based on the
magnitude of the load applied by the operator and the dynamic background calculation of Formula (1), Formula
(2), Formula (3), Formula (4). According to the results of calculation, the three-dimensional modeling
technology was used to real-time display in the man-machine interface display, so that experimental realism
increased. Three-dimensional modeling technology in the man-machine interface real-time display, so that
experimental authenticity increased.

3.6. Other pre-show of network experiments

Experiment and practice process networking, the advantages of network teaching can be fully
used(YIN, 2014):
- No time and space constraints (anytime, anywhere on-demand network teaching);
- Multi-level (basic knowledge, comprehensive training, professional design, innovative research projects);
- Fully open (network resources are fully open);
- Interactive (teacher and student interaction online);
- Cooperative (student team independent learning).

Experiment and practice process networking, students can have a better understanding of the experimental
purpose, principles, laboratory equipment, experimental processes in advance, and have full pre-preparation for
the late work, directly brought a well experimental teaching effect. The networking of experiment and practice
greatly promoted the original experimental equipment networking process.

The networking of experiment and practice make the teacher facilitate to master the experimental situation
of students’ completed, to understand when students make an appointment, when to complete the experiment,
and also to know the experimental project name, experimental results, as well as problems in the course of the
experiment. All of which is conducive to the teacher’s overall control of the progress of the experiment.

4. UNDER THE CONDITIONS OF INFORMATION EXPERIMENTATION IN THE FUTURE
DEVELOPMENT OF IDEAS OR DIRECTION

4.1. Design of Internet pattern for Experimental Equipment

According to the Ministry of Education on the principle of virtual simulation laboratory positioning, the
experiment should be “virtual experiment combined with traditional experiment; complement each other; can be
done with traditional experiments do not use virtual experiments”. Although the virtual simulation experiment
has broad prospects for development, but the traditional experiment has a very important position. “Can be done
with traditional experiments do not use virtual experiments” and “Supplement traditional experiment with
virtual experiment” is the main principle. In the face of the rise and flourish of the network classroom, such as
MOOCs class, the remote experiment is a bottleneck, which restricts the development of the network classroom.
Therefore, in the near future or in the future, it will be a promising research field for the transformation of
traditional experimental equipment to Internet of Objects.

4.2. Dangerous and inaccessible experimental areas

These experiments are an important part of the theoretical teaching, but the experiments are difficult to
carry out, for the dangerous or hazardous or radioactive items. Therefore, the best way to solve these problems
is to replace traditional experiment by virtual simulation.

4.3. A place of confusion or serious interference

In practice teaching, there are many such scenes. The noisy scene of practice, the teacher’s teaching was
overwhelmed by the scene, cannot be heard; For safety, many drilling team is not to let the students arrive at the
drilling deck. The practice of drilling field teaching cannot be realized. Still other scene such as high pressure
field, severe radiation exposure field, explosive dangerous field, and so on. These fields are also the driving
force and the urgent requirement for the development of simulation experiments.

5. CONCLUSION
In the traditional experimental teaching, there are many anachronistic situations, present many cannot meet the development of higher education, many uncoordinated between development of science and technology and the status, all of which seriously affected the education and the new era of talent cultivation. It can better solve the contradiction in the traditional experiment with the development of computer technology, three-dimensional modeling technology, simulation software technology, network technology and other research and development of virtual simulation technology. In this paper, the successful development of the virtual simulation experiment technology can provide guidance for other organizations and individuals to prepare for the development of virtual simulation experiments. The direction of information technology and future development in the future is pointed out. The development of virtual experiment, as well as the development of network technology to achieve the sharing of resources was eliminated the phenomenon of uneven resources among universities, for the whole society to contribute to equal education.

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