

Research on the Application of Virtual Simulation and 3D Animation Technology in the Teaching of Road and Bridge Majors in Higher Vocational Colleges

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Abstract: The informatization of higher vocational education is the future development trend, and it is also encouraged and promoted by the Ministry of Education. This article focuses on the road and bridge major, combined with the author's experience in introducing virtual simulation and three-dimensional (3D) animation technology into relevant course teaching in recent years, discusses the application of virtual simulation and 3D animation technology in higher vocational education and promotes classroom revolution, to obtain better teaching effect.

Keywords: Virtual simulation technology; 3D animation technology; Higher vocational education; Classroom revolution

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1. Introduction

In recent years, the Ministry of Education has been promoting the reform of higher vocational education, emphasizing the improvement of the level of higher vocational education and cultivation of skilled and technical talents that meet the needs of social industries. "Vocational Education Quality Improvement and Training Action Plan 2020–2023" and other documents reflected their efforts to promote the reform of higher vocational education.

In this context, many new technologies, such as virtual simulation technology, three-dimensional (3D) animation technology, Building Information Modeling (BIM) technology, etc., have been introduced into daily education and teaching in higher vocational colleges. Among them, the application of virtual simulation technology is pervasive, and there have been many application practices in the teaching of civil engineering^[1-4], aerospace^[5], and mechanical manufacturing^[6]. There is relatively less application of 3D animation technology in teaching, but there are also many application cases in civil engineering construction.

2. Virtual simulation and 3D animation technology

In the talent training programs of higher vocational colleges, practical class hours often account for more than half of the total class hours, which puts high demands on the school's applicable training conditions. Taking the road and bridge major as an example, courses such as road and bridge construction and testing courses involve many practical training projects. This practical training needs to rely on various construction environments and mechanical equipment. The operability still needs to be improved. Virtual simulation technology and 3D animation technology can solve these problems efficiently.

Virtual simulation technology is a new technology that uses computers and special physical effect equipment to conduct relevant dynamic experimental research on actual or imaginary systems with the help of corresponding system models. Various simulation software that can simulate the construction process of roads and bridges has appeared on the market. In these software systems, students are placed in a virtual construction site and they can roam, watch, or complete the construction process themselves. **Figure 1** shows a virtual simulation scene of foundation pit engineering construction.



Figure 1. Virtual simulation scene of foundation pit construction

3D animation technology is now commonly used to introduce construction techniques such as housing construction, roads, bridges, and tunnels. 3D animation technology is a technology that simulates the dynamic behavior of three-dimensional objects in physical space with the help of computer programs. It can turn a static 3D model into a real and vivid animation effect through a series of steps such as making a 3D model, designing actions, designing lighting, and adding special effects. Many construction units usually use 3D animation technology to create 3D animation demonstrations of complex construction processes when conducting project reports or technical disclosures. These are intuitive, simple, and easy to understand ^[7-9], as shown in **Figure 2**. These 3D animations are scarce case materials for road and bridge majors when they learn construction technology.

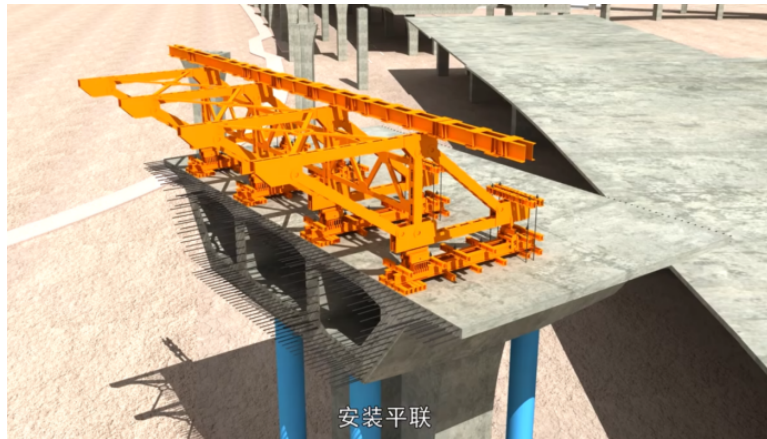


Figure 2. 3D animation clip of bridge construction hanging basket assembly

3. Application in teaching practice

3.1. Application of virtual simulation technology in teaching practice

The application of virtual simulation technology generally relies on various professional virtual simulation software. This virtual simulation software usually includes several simulation projects. Taking the road and bridge engineering simulation training software developed by a particular company as an example, we introduce the application of virtual simulation technology in the “Bridge and Culvert Engineering Construction Technology” course and “Expanding Foundation Construction” training teaching.

- (1) Initially establishing the construction site image by looking at the picture

Since the images of the virtual simulation are illusory and not the actual scene of the construction site, it is necessary to first expand the construction pictures of the primary site so that students can establish an impression of the construction site. In this step, collecting many real on-site construction pictures is essential, which can be introduced to students through multimedia PowerPoint presentation (PPT) courseware.

- (2) Entering the virtual simulation space

The virtual simulation space (learning mode) is entered with the help of the expanded primary construction project case established by the simulation software. During the pre-class preview, the background information of the engineering project is released for students to get familiar with it. When teaching, the teacher explains while operating and completes the process. Next, let the students complete the simulation of the entire construction process on their own.

- (3) Learning specific construction segment

There are multiple construction segments in the expanded foundation construction, and the learning of each construction segment follows the following learning process:

First, the instruments, tools, or equipment used in construction are selected. The instruments and equipment or construction machinery and building materials are different for each construction segment. The principal tools or construction machinery used in this segment must be selected. If the selection is wrong, the subsequent process cannot be advanced.

Next, relevant knowledge in the construction process is learned. In every construction segment, there are some knowledge points to grasp. Some of these knowledge points may be the selection of appropriate equipment, or it may be the technical requirements of this construction segment, or some conventional construction knowledge, which needs to be especially reminded for students to be

familiar with. Some essential knowledge points appear as multiple-choice questions in the simulation software and are mastered by letting students answer the questions. For some software systems that are not mentioned, the instructor can add them in addition.

The virtual simulation images and on-site construction scenes are compared. After all, the virtual animation scene is fake. In order for students to know the construction site, for some critical construction segments, it is still necessary to combine accurate site pictures for students to get a more authentic understanding.

The assessment is completed when the entire construction technology study is conducted. There are two types of assessment content. The first is to assess how well the students have mastered essential knowledge points in the construction process, the second is to determine how well the students have mastered the entire process. The first assessment method can directly extract the exercises in the simulation software database and allow students to answer them. The evaluation basis is the correct rate of activities. The second assessment method will enable students to operate and simulate the entire process, and the evaluation standard is the time students take to complete the whole process.

3.2. Application of 3D animation technology in teaching practice

The 3D animation produced by 3D animation technology plays a vital role in case teaching. At present, major video websites and some animation production companies share a lot of road and bridge construction process animations on the Internet. These are rare and valuable engineering case materials in road and bridge professional classrooms.

Compared with traditional construction pictures and some construction short films shot at the construction site, construction animation is not limited by work space and time constraints. While a bridge can take years to build, construction animations allow students to watch the entire bridge being constructed in minutes. The construction conditions, mechanical equipment, technicians, quality standards, etc., are all available, and the whole technological process is compact, complete, and very vivid, which is convenient for students to grasp the entire specialized construction method.

The following is a section of the bridge superstructure hanging basket method construction in the “Bridge and Culvert Engineering Construction Technology” course, the structure and installation of the hanging basket is taken as an example.

The hanging basket is the leading equipment in the cantilever construction of the bridge span structure, and its design is relatively complicated. **Figure 3** shows the construction site for installing the hanging basket.



Figure 3. Photo of the installation work of the hanging basket at the construction site

- (1) Preview: 3D animation of the hanging basket installation and construction is uploaded in the teaching resource library of the designated learning platform, and students are required to watch the animation before class to get a preliminary understanding of the structure and installation process of the hanging basket.
- (2) In-class explanation: Students' preview situation is checked and reported through the learning platform. Next, the traditional PPT teaching courseware combined with 3D animation video is used to explain the structure and installation of the hanging basket.

Since neither the virtual simulation nor the 3D animation shows the actual hanging basket, combining the learning with the actual pictures is necessary. These actual pictures are integrated into the PPT courseware, and comparing the virtual and the real construction site makes it easier for students to understand.

The installation and construction of the hanging basket is a dynamic and continuous process, and it is difficult to show this process only by pictures. Therefore, when explaining the installation of the hanging basket, the 3D animation demonstration is mainly used. During this process, the equipment tools, installation requirements, safety precautions, etc., required for each installation step are usually not explained in detail in the animation and can be supplemented by teaching courseware.

- (3) Homework: Through the exercise library in the teaching resource library, assign after-school homework is assigned and the learning effect is checked.

4. Summary of the application effect

Judging from the teaching effect in recent years, the reform effect is very significant. Some monotonous courses, such as road construction technology, bridge construction technology, and other convenient courses, became lively and exciting, and students' learning enthusiasm was significantly improved.

4.1. Summary of virtual simulation technology application

Virtual simulation technology relies on virtual simulation software, which requires schools to purchase software and invest in establishing simulation training rooms. Although it is expensive, the investment is much more economical than building physical training facilities.

Since the virtual simulation software comes with a virtual simulation project, creating a corresponding resource library is unnecessary, and it can be used directly. However, this simulation software usually has limited resources. For example, the road and bridge simulation software purchased by the author's school has 28 simulation learning modules. It covers six significant areas: road and bridge engineering measurement technology, cost, and inspection technology, bridge structure design, road engineering construction technology, and bridge engineering construction technology. For simulation courses, on average, there are very few simulation items in each class, and it is challenging to cover the teaching content of the entire system. Therefore, content other than simulation software must rely on 3D animation technology through case teaching. The simulation projects that come with the virtual simulation software can be developed into practical training courses.

4.2. Summary of 3D animation technology application

3D animation technology can be used to make 3D animation videos and it is currently widely used in the engineering construction market. Unlike the virtual simulation software that comes with simulation projects, self-development faces technical bottlenecks, thus collecting video data and creating a resource library is

necessary.

There are two sources of animation video resources for the creation of the resource library. One of the resources is that on major video sites, many animation production companies share some 3D animation videos of road and bridge construction, which are used by production companies for self-promotion. Others are 3D display animations produced for technical disclosure or project technical introduction during the construction of some road and bridge projects. The second resource is that some online learning platforms created by the national education department, such as China University MOOC, share resources and some animation videos.

Although the use of 3D animation technology in case teaching requires the creation of a resource library, the advantage is that the resources are abundant, and the content is comprehensive, which can generally cover more critical or challenging points in the course.

4.3. Combination of new technology and traditional teaching

In the previous traditional teaching of higher vocational colleges, multimedia projection PPT courseware lectures were generally used. Some colleges and universities have also established online learning resources such as online courses and micro-classes, which provide new ideas for teaching road and bridge majors in higher vocational education. However, due to the lack of teacher supervision, these online learning has generally less application, and the usage rate in higher vocational students is low. They should be balanced and can only be used as auxiliary teaching.

Virtual simulation software can support students to experience the implementation process of the project by themselves, which is an excellent choice for practical training courses. 3D animation video resources are abundant with a wide range, which can be used for theoretical teaching or developed into practical training courses, depending on the content and detail of the video.

Although these new technologies and resources have significantly reduced the workload of classroom preparation, they must not be relied on alone. They must be combined with traditional multimedia courseware teaching to complement each other to obtain the best learning effect.

5. Conclusion

Educational informatization and classroom revolution are the general directions of higher vocational education reform required by the education department in recent years. Combined with the development of more and more advanced computer technology, making full use of virtual simulation and 3D animation technology is the development trend of higher vocational road and bridge professional education. Higher vocational teachers must not only actively learn and apply these new technologies, but also gradually abandon the traditional single multimedia courseware teaching method, develop new teaching methods, and continuously promote teaching reform to cultivate highly skilled application-oriented road and bridge construction talents who meet the needs of the country and society.

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References

- [1] Zhao Q, 2022, Exploration and Construction of Civil Engineering Virtual Simulation Experiment Teaching System. *Science and Technology and Innovation*, 2022(17): 1–3.
- [2] Wang S, Zhang P, Chen X, 2021, The Current Situation and Sustainable Development of Virtual Simulation Practical Teaching in Civil Engineering. *Education and Teaching Forum*, 2021(12): 37–40.
- [3] Ge W, Tang R, Song W, 2021, Application of Virtual Simulation Experiment in Teaching Civil Engineering. *Journal of Yangzhou Vocational University*, 25(04): 55–58.
- [4] Wang G, Wan T, Li H, et al., 2019, Teaching Research on Civil Engineering Major Based on Virtual Simulation Technology. *Journal of Baicheng Normal University*, 33(10): 71–73.
- [5] Zhang H, Tang K, He L, et al., 2023, Research on the Application of Virtual Simulation Technology in Teaching Railway Vehicle Technology. *Automobile Education*, 2023(11): 77–79.
- [6] Liu J, 2023, Application and Thinking of Virtual Simulation Technology in Aviation Professional Training Teaching. *Vocational Technology*, 22(4): 76–83.
- [7] Chen Y, Chen J, 2011, Application of 3D Animation Technology in Building Construction. *Guangdong Civil Engineering and Architecture*, 18(05): 28–30.
- [8] Wang J, n.d., Application and Research of 3D Animation Technology in the Simulation of Building Construction Process. 2007–2010.
- [9] Xu Q, Zhu E, Zhang W, 2002, Three-Dimensional Animation Simulation Technology of Bridge Construction Process. *Building Construction Technology*, 2002(11): 39–41.

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