Research on case virtual simulation teaching system for automobile engine based on Web 3D

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Abstract. At present, the traditional teaching methods rely on paper teaching and specific physical equipment, which is a lack of immersion. Moreover, it is experimentally costly and the teaching effect is not good. Therefore, this paper proposes a Web 3D virtual simulation teaching system for automobile engine based on case teaching method. The system mainly includes three modules: account management, 3D virtual simulation teaching based on typical cases and document reading. Unity3D software and database technology are used to build a realistic virtual experiment scene, so that students can simulate interactive experiments online and master learning skills to achieve teaching objectives. The experimental results show that the 3D virtual simulation teaching system proposed in this paper can realize online simulation of specific interactive experiments of disassembly and assembly for automobile engine. In addition, students can learn independently, so as to achieve the purpose of immersive learning, improve teaching efficiency and reduce costs. Most importantly, it can avoid teachers and students from being hurt in the actual experiment and provide a new way for teaching.

1. Introduction

In university teaching, teaching methods mainly include face-to-face courses and experimental courses. The former often lacks immersion and concrete feelings, the latter often requires expensive experimental materials and long preparation of experimental equipment. Compared with the traditional teaching method, the 3D virtual simulation teaching system realizes the online function, which reduces the time and money cost required by the experiment. At the same time, 3D virtual simulation technology allows students to have a strong immersive experience. Therefore, the exploration of simulation experiment is a hot research topic in the development of online teaching.

Therefore, many relevant scholars at home and abroad have carried out research. Younes Kadi and Khalid Satori used Unity3D to design a complete virtual 3D graphical environment that was applied to the training system of fighter pilots [1]. However, their proposed teaching system lacks online interaction, so the system lacks convenience and immersion. The teaching system combining 3D spherical panorama and virtual reality proposed by Barkatov, Igor V. et al. is mainly applied to military and civilian vehicles [2]. This system allows students and teachers to conduct teaching activities without the use of large or dangerous laboratory equipment. Ke, Fengfeng and Xu, Xinbao proposed a collaborative and situational micro-teaching practice. After the virtual simulation teaching, the students' knowledge improved significantly. However, they do not have a teaching system that combines Unity3D with the website, and it is not convenient for students to submit homework and teachers to correct, which fails to meet the needs of distance teaching. Nicholas Lanzieri designed a
more powerful alternative using the Wonda VR™ platform, 360 video editing software for producers [4].

Virtual simulation technology based on 3D has become a hot wave of research, but most of the current teaching systems still have many shortcomings. Especially, it is difficult to combine with the education method, and the best effect of education and teaching cannot be achieved. Therefore, through the combination of case teaching method, a set of Web3D based virtual simulation teaching system for automobile engine is developed, which reduces the teaching cost, improves the man-machine interaction, and significantly improves the teaching effect.

2. Case virtual simulation teaching system realization

The 3D virtual simulation teaching system can be divided into three parts: account management, virtual simulation cases and data sharing. Account management can be the student system registration, login, management information, the administrator can modify the information background. 3D virtual simulation case teaching can carry out 3D virtual simulation exercises and homework submission based on the case. Data sharing can be used to obtain relevant materials for teaching. The functional results of the system are shown in Figure 1.

![System functional framework](image)

**Figure 1.** System functional framework.

2.1. Account management function

Student account. This system uses SQLServer2019 as the database, and constructs two tables in the database to store the information of students and administrators respectively. At the same time, the system uses ASP.NET UI interface design, and the user account management. When using the system for the first time, students need to set up their own user name, password and other information and submit it. After that, the Student table in the database will store the information of students, and students can log into the system with their account and password. Students can change their password at any time by clicking on the left side of the login page. After the student updates the password, the corresponding letter student information of the database table will also be updated.

Administrator account. In order to manage the account in the database, the administrator login function is added, and the Admin table is added in the database. The administrator also has an account and password to update the Student and Admin tables in the database. In addition, administrators can make changes to student work.

2.2. Virtual simulation experiment based on case teaching method

Virtual simulation experiment based on case teaching method is the core module of this system. The concrete steps are as follows:

- Step 1: In the relevant practical courses, teachers select classic parts, such as the most core parts of the automobile -- automobile engine, as the typical operation object of the system. Key Operation in automobile maintenance -- Select the disassembly and assembly of automobile
engine as a typical study case. According to the learning points and difficulties, this system will summarize the interactive process sequence of virtual simulation cases.

- **Step 2:** For virtual simulation of disassembly, this system uses 3DMAX to conduct 3D automobile engine modeling and saves it as FBX mode. Then, the experimental scene of case disassembly is selected and import the scene model and engine model in Unity to build an immersive case scenario model. At the same time, according to the typical cases selected before, the dismantling steps are designed in turn, subdivided into each small step that can be scored. Import the release model file exported by Unity into the asp.net in visual studio and write the underlying C# code. This module allows students to observe the disassembly position and the state change while clicking on the part. Each time when students click a part in the right order, they get an extra ten points. Otherwise, they get no points. Until the disassembly comes to the final step, the student's final score is stored in the database. Students can do experiments for many times, which is convenient for repeated practice to deepen the impression.

- **Step 3:** Automobile engine assembly is the reverse process of the interactive process design of disassembly simulation, which can be realized by the reverse design according to the sequence of engine disassembly in the step 2.

2.3. **Document view**
The system has set up two document reading function modules.

1. Writing Laboratory Operation Specifications and Experimental Instruction after practical operation and experimental specifications;
2. Two documents will be converted into PDF documents;
3. Place the two PDF files in the "Experiment Overview" directory;
4. Click two buttons on the left to view the PDF file on the right. Compared with the ordinary browser to view PDF, the system can display the viewer on the left side of the document catalog, the right side of the document can display the single page content, support the scroll wheel under the page operation.

3. **Experimental results and analysis**

3.1. **Experimental results**
Students are required to fill in the account, name, gender, grade, class, password and other personal information and verification code to complete the registration, before returning to the login page for login operation. After login, users are able to enter the system, where the page is as shown in the figure 2. On the left are the general directories and subdirectories of the system. The system is shown on the right.

Before conducting virtual simulation teaching, students are required to view the experimental operation instructions and specifications. Students are able to view the corresponding PDF documents on the right by clicking the laboratory operation specifications (Figure 3) under the experimental overview on the left, as shown in the figure. The right display page can be viewed on the left side of the PDF thumbnail.

After viewing the document, the students click the left button: automobile engine disassembly to enter the virtual simulation teaching, where there are two processes in this link: disassembly and assembly. The disassembly process of automobile engine is divided into 10 steps. If the total score is 100 points, each step is 10 points. For instance, Figure 4 (a) and (c) show the automobile engine in a fully assembled state and a fully disassembled state. As shown in Figure 4(b), click to the fourth step of the automobile engine disassembly process. If the operation is correct, the corresponding score is 40 points, the score is displayed in the lower right corner, and the number of remaining steps will be displayed as a reminder in the lower left corner of the page. Additionally, the assembly process of the automobile engine is the inverse process of the disassembly process.
After completing the experiment, students are required to write a report on the experiment. Click the report submission page on the left, fill in the experiment report and submit it, as shown in Figure 5.

Figure 2. User login interface and Student registration interface.

Figure 3. Laboratory operating specifications.

Figure 4. (a) Undisassembled model in the case-based 3D virtual simulation teaching system.

Figure 4. (b) The model of the fourth step in the case-based 3D virtual simulation teaching system.
4. Conclusion
This paper presents a set of Web 3D Virtual Simulation system, which enables the students to do virtual interactive disassembly experiments of automobile engine online. This system not only provides students with immersion, but also improves the efficiency of teaching and eliminates the risk of students' on-site production practice experiment without training. This system can be widely used in fields like power station, precision instruments, military, aerospace, manufacturing, and has important application value.

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