Development and Practice of Virtual Experiment Platform Based on Blender and HTML5--Taking Computer Assembly and Maintenance as An example*

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Abstract. The use of virtual training, can solve the problems such as the shortage of training resources, slow update of equipment, lack of training supplies, risks and environmental pollution and other issues in pure physical equipment training. This paper applies Blender and Html5 technology to student’s experiment in colleges and universities, and designs an interactive virtual experiment platform which integrates learning and experiment and supports multi-terminal visualization. The design scheme, main function and implementation technology of the platform are introduced in detail, and applied to the course of computer assembly and maintenance. First, the 3D model is constructed by the free open source modeling software Blender and exported in a specific format recognized by the WebGL library. Then, this library is used to add interactive function for the application program, which can realize the real-time interaction between user's Browser and 3D model. HTML5 is used to eliminate the problem of customizing special web pages for different devices, and adaptive page design is realized to support multi-terminal access. Based on this platform, the virtual reality learning system of computer assembly and maintenance was designed. After the completion of the study, knowledge acquisition, skill assessment, psychological feeling and cognitive load were measured. Practice shows that the application of this technology can enhance the immersion and intelligence of the experimental process, and improve the user's interaction and experience. At the same time, the system has a cross platform, free plug-in, easy maintenance and other characteristics, can solve the problems of poor user experience and compatibility of traditional virtual experiment platform.

1. Introduction
Experimental teaching, which is an important part of higher education, can strengthen students' comprehensive quality and cultivate students' practical skills, but the experiment equipment, funding and risk weakness restrict the development of skills in the experimental teaching. In the ten-year development plan for educational informatization (2011-2020), the Ministry of Education emphasizes the construction of informationized teaching facilities such as simulation training bases, the construction of management information systems in key business areas such as internship and training, and the establishment of a digital environment supporting students, teachers and employees independent learning and scientific management.[1] Under the guidance of this, colleges and universities have carried out active reform and exploration on practical training in recent years, and achieved remarkable results.
The virtual experiment provides multi-perception virtual space by simulating real environment, which meets the needs of learning, exploring and experiencing in virtual environment [2]. However, the current virtual experiment system mainly has the following problems: (1) lack of interaction, most of them still focused on the demonstration type of virtual experiment, experiment interaction is poor; (2) the traditional virtual experiment has the problems like plug-in dependence, different standards, integration, poor closure, and other problems, affecting the user's higher level of experience and perception; (3) C/S, rich client mode virtual experiment system can not meet the ubiquitous, fragmented mobile learning requirements of learners. Therefore, it is particularly necessary to build a virtual experimental system with good human-computer interaction performance, which can be applied to all kinds of terminals without plug-in dependence and can maximize the learning needs of students anytime, anywhere.

2. The system structure of online virtual experiment platform

2.1. Create 3d models in Blender

The system structure of the platform is shown in Fig. 1. First, build a 3D model with Blender. The establishment of 3d model is very important in the virtual experimental environment. The fidelity of 3d model directly affects the authenticity of the virtual environment and the immersion experience of students. A realistic virtual experimental environment can give students a strong sense of presence, which “promotes the generation of Flow”. [3] HTML5 can draw graphics through Canvas object, WebGL and other technologies, but the drawing technology is too complex, and commercial modeling software such as Maya and SolidWorks is expensive. Considering the compatibility, economy and other factors of the development platform comprehensively, this study adopts open-source Blender, which supports high-quality modeling, animation and rendering, as the modeling software. [4] Although Blender is free and open source, it has powerful modeling functions, rendering, animation, post-processing, cross-platform 3D interactive production and other functions. Meanwhile, Blender can also be exported into the JSON format that can be recognized by three.js.

![Systematic structure diagram](image)

2.2. Real-time interaction of 3D models

Three.js provides export plug-ins for Blender, Maya and 3DMax, but only plug-ins for Blender can support export animation. Three.js was developed by Miguel[5], a Spanish programmer. In essence, three.js is a WebGL third-party library written by JavaScript. It can edit the newly defined CANVAS tag of HTML5 through WebGL to achieve the function of displaying on the webpage. Three.js abstracts the native API details of WebGL and is able to create a variety of 3d scenes in the Web, such as 3d
objects, lights, shadows, materials, etc. [6]. Compared to traditional Web3D, users can directly control the
3D scene on the Web page through JavaScript without having to install plug-ins in the browser. Three.js solidifies the support for Picking, so it is easy to add interactive functions for the application, and the platform realizes real-time interaction between the user's browser side and the 3D model.

2.3. Achieve cross-platform and cross-terminal access through HTML5
HTML5 and CSS3 are two new standards proposed by the World Wide Web consortium and its working
group, which are applicable to cross-platform applications[7]. HTML5 includes richer descriptive tags,
better cross-site communication, cross-window communication to animation and complete multimedia
support, without the need for Flash, Silverlight and other plug-in technology can achieve video audio
playback and vector picture browsing and other functions. At the same time, it eliminates the problem
of customizing special Web pages for different devices and completely realizes adaptive Web design.
In addition, it provides extremely powerful API, which can be used to develop strong interactive Web
applications and create richer and more powerful Web applications.[8]

Figure 2. System technical solution

The key technologies adopted in this paper are shown in Fig.2. The virtual experiment platform is based
on Microsoft Visual Studio 2013 and ASP.NET platform. The front-end WEB interface uses CSS3,
Canvas, Java Script and other technologies. When designing, it combines the new technology of HTML5
to process some logic functions in the foreground to reduce server pressure. CSS3 provides different
styles to control the performance of structural documents. Java Script and Jquery are used to dynamically
control CSS and HTML elements in the web page interface. Canvas drawing technology is used to
realize the screen display. Using SQL Server 2008 as the back-end database software, the system uses
a combination of file storage and database storage to store data, that is, the 3D model is stored in two
ways according to the piece path and binary stream, which not only facilitates unified management of
data but also improves the security of data in the system.[9] Since modeling on the Web involves
bandwidth, the model itself cannot be too large, and the data format of the model is in lightweight JSON
format, which can match well with Three.js. Because the Web is a real-time interaction, and the model
data is transmitted asynchronously in the background, the communication between the client and the
server adopts the AJAX method. The program accesses the WebService through HTML and AJAX, and
the WebService is responsible for the network data transmission, and finally realizes the remote access
in coordination.
3. System function modules

The main modules of the system are: experimental project selection module, experimental support module, feedback and evaluation module, cooperation and communication module, platform management module. The system function module diagram is shown in Fig. 3:

3.1. Selection of experimental projects

The system mainly consists of virtual assembly and virtual disassembly of single project, virtual assembly and virtual disassembly of the whole machine, and computer fault maintenance module. Each experimental module is comprised of a specific virtual experimental unit, which is the core part of the platform. The platform adopts role-based access control. Students log on to the virtual experiment platform and select the corresponding virtual experimental unit for experiments. In each virtual experimental unit, the system provides two options: automatic demonstration and manual operation. Automatic roaming is to disassemble and install according to the path designed by the platform and provide disassembly details, which is convenient for preliminary learning and avoid blind operation. Manual operation enables the user to interact with the keyboard and mouse in the built virtual scene and perform virtual operation.
Figure 3. System function module
3.2 Experimental support
In order to improve experimental performance, the platform has created an excellent digital learning environment for students, and provides students with multimedia resources, e-learning notes, experimental report writing, synchronous and asynchronous communication and other learning support tools, which is also the practice of student-centered, teacher-led teaching philosophy.

3.3 Feedback evaluation module
This module mainly provides learning track tracking, questionnaire survey and information feedback, and teacher guidance record query. The recording of student experiment process is mainly to track and record the time, duration and frequency of students' online experiment as well as the amount of interactive question-answering in the course, so as to provide important learning record data for the evaluation of learners' learning behavior and effectiveness. It can also motivate and adjust students' learning behavior. Online survey and feedback are used to understand students' needs in real time adjust experimental teaching strategies in time and promote the improvement of experimental performance.

3.4 Platform management function
This module is aimed at the experimental management personnel of the school. The purpose is to provide a fast, concise, visual and standardized management platform for virtual experiment platform management, which makes the experimental management personnel of the college more standardized and faster in system management, mainly including announcement management and users management, content management, performance management, etc.

4. System features and application effects

4.1 Hardware cognition
The completed “Microcomputer Assembly and Maintenance” virtual training platform system version 1.0 has been able to achieve the expected results.

After the student has registered and get the administrator's approvals, they can log in to the network virtual lab. Select the appropriate experimental unit with the help of the navigation menu. The view angle and viewpoint position can be changed in real time through the keyboard or mouse to realize real-time interaction with the 3d model of computer parts, and the 3d model can be enlarged and further understood through the mouse wheel. As shown in Fig. 4, after logging in, students can use the mouse to rotate, translate, drag and drop the selected desktop motherboard, observe it from any Angle, and further deepen their understanding of the details of components by using the zoom operation. Fig.5 shows for students exploring the motherboard of laptops through mobile terminals.

![Figure 4. Access through the PC](image1)

![Figure 5. Access through the mobile](image2)
4.2. Assembly and disassembly
The virtual platform provides two modes: automatic presentation and manual operation, automatic demonstration let students be familiar with the operation process by means of automatic roaming. Clicking on the automatic demonstration will play the 3D animation of the corresponding parts installed or disassembled, and the position of the computer parts in all directions, installation sequence, and precautions are presented for students to have a visual experience before manual operation. Manual operation is to allow students simulate installation interaction through mouse dragging (mobile terminal is interactive by hand). Interactivity is of huge significance to the virtual environment. Only scenes with interactivity are more attractive, making people have an immersion feeling. Interaction not only makes it easier for students to adjust to the new learning environment, but also improves students' learning enthusiasm and initiative. Fig. 6 shows the red arrow indicating the CPU's golden triangle position to be aligned with the golden triangle position on the slot when installing the CPU into the slot on the motherboard.

![Figure 6. CPU installation](image)

![Figure 7. Memory fault](image)

4.3. Malfunction repair
In order to accumulate students' practical experience and improve learners' cognitive ability, the system sets common computer failure cases to enable learners to determine the cause of failure and propose troubleshooting solutions. In the process of troubleshooting, students through warning sound plus popover to help students correct mistakes in a timely manner. At the same time for learning and reference, the system is also given the failure state and normal picture and animation information. Fig. 7 shows the performance support information given by the mobile terminal system when students deal with memory failure.

5. Results and discussion
To analyze the learning behavior of users in the virtual experimental environment and improve the function of the platform, we recruited 66 students to use the virtual training platform to learn computer assembly courses. After the course, 60 valid questionnaires were collected through questionnaires. The questionnaire contains user background information, usability testing, etc. The usability questions were based on the technology acceptance model (TAM), including perceived ease of use (PEOU), perceived usefulness (PU) and perceived interest (PP). Level 5 Likert scale was used in the evaluation scale, of which 5 was the highest score (indicating full compliance) and 1 was the lowest score (indicating complete inconsistency). It took 10 to 15 minutes to complete the normal answer. Questionnaire data were analyzed by SPSS 22.0

On PEOU, all participants agreed that it was easy to interact in selecting objects, moving, rotating and changing perspectives. As shown in Table 1, The median scores were all above 4.
Table 1. Questionnaire statistics of QEOU

|                                                                 | N  | Mean | Std. Deviation | Variance |
|-----------------------------------------------------------------|----|------|----------------|----------|
| It is easy for me to grasp the object in the scene               | 60 | 4.07 | .800           | .640     |
| It is easy for me to move the object to the specified spot      | 60 | 4.18 | .854           | .729     |
| It is easy for me to change perspectives                        | 60 | 4.12 | .922           | .851     |
| It is easy for me to choose the item                            | 60 | 4.10 | .838           | .702     |
| It is easy for me to move the place that I want to              | 60 | 4.10 | .817           | .668     |
| It is easy for me to disassemble and assemble the components   | 60 | 4.38 | .490           | .240     |
| It is not difficult interact in the scene                       | 60 | 4.02 | .873           | .762     |
| The indication from the system is clear for me                  | 60 | 4.03 | .938           | .880     |
| It is easy for me to self-direct pace of learning               | 60 | 4.13 | .769           | .592     |
| I find it flexible to operate in the scene                      | 60 | 4.10 | .969           | .939     |
| Valid N (list wise)                                             |    |      |                |          |

For PU, that is, perceived usefulness, we find that the median of all problems is above 4 (as shown in Table 2. Most learners believe that the system is useful. Demonstration and assembly tasks of disassembly provide users with an opportunity for practical and operational learning.

Table 2. Questionnaire statistics of PU

|                                                                 | N  | Mean | Std. Deviation | Variance |
|-----------------------------------------------------------------|----|------|----------------|----------|
| Freely operating machine enables me to know the machine well    | 60 | 4.15 | .820           | .672     |
| The explanation on components of computer enables me to enhance the memory of knowledge | 60 | 4.27 | .821           | .673     |
| Freely operating virtual components enables me to recognize their characteristics | 60 | 4.23 | .851           | .724     |
| The demonstration of disassembly and assembly enables me to learn how to work on assembly | 60 | 4.13 | .853           | .728     |
| I think it is useful to observe 3D objects from different perspectives | 60 | 4.15 | .777           | .604     |
| Virtual assembly enables me to improve my skills                | 60 | 4.38 | .524           | .274     |
| Virtual assembly enables me to increase my knowledge on composition of the computer | 60 | 4.03 | .882           | .779     |
| Simulated virtual assembly enables me to improve my memorizing skills | 60 | 4.88 | 6.517          | 42.478   |
| I think virtual reality is useful for studying computer assembly | 60 | 4.18 | .792           | .627     |
| Valid N (list wise)                                             |    |      |                |          |

In Table 3. We find that the median is more than 4. Most learners believe that the platform creates an interesting learning environment in terms of learning content, game interaction and task training.
Table 3. Questionnaire statistics of PP

|                                         | Mean | Std. Deviation | Variance |
|-----------------------------------------|------|----------------|----------|
| I find it interesting to move virtual objects | 4.07 | .800           | .640     |
| II find it interesting to grasp virtual objects | 4.18 | .854           | .729     |
| I find it interesting to freely move myself in VR | 4.12 | .922           | .851     |
| I find it interesting to select interactive items in the scene | 4.10 | .838           | .702     |
| I find the tasks set in the simulated assembly interesting | 4.10 | .817           | .668     |
| I find it interesting to assemble in the virtual | 4.38 | .490           | .240     |
| I find the immersive virtual reality scenes interesting | 4.02 | .873           | .762     |
| Valid N (list wise)                      |      |                |          |

6. conclusion
The interactive virtual experiment platform proposed in this paper is developed with Blender and HTML5 technology. It has the characteristics of cross-platform, high interactivity and no plug-in dependency. This platform can meet the requirements of ubiquitous and fragmented mobile learning of students, saving the cost of purchasing and managing and maintaining hardware, and has strong practical significance. However, how to better increase the immersion of students in the experiment and the interest in the interaction process on this virtual platform, realize the collaboration of students in the experiment, and use this platform for blended learning, etc. still need further research. In the follow-up study, the author will continue to improve the virtual experiment platform and improve the virtual experiment effectiveness as a whole.

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