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# The Immersive Teaching and Smart Interactive Training Platform for Virtual Simulation System in Educational Reform Application

**Zhijian Huang[1*], Xiankun Wu[2], Chenghui Jing[1]**

[1]Lab of Intelligent Control and Computation, Shanghai Maritime University, Shanghai, China
[2]Digital Science College, Shanghai Lida University, Shanghai, China
Email: *zjhuang@shmtu.edu.cn

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## Abstract

The disassembly and assembly of marine oil-separators is a core experiment in marine engineering. To overcome the limitations of traditional physical disassembly and hands-on training, this study employs the implicit three-dimensional (3D) reconstruction theory. By utilizing a large dataset of high-definition images captured from specific angles and leveraging the Laplacian operator-based deep neural network Neural-Radiance-Field algorithm, high-precision 3D models of the oil separator body and its components are rapidly constructed. Subsequently, voxel rendering is performed, and finally, the Unity 3D is utilized to develop an immersive teaching and interactive virtual disassembly system for marine oil-separators. This system features high model accuracy, immersive experiences, and intelligent interactive operations. By serving as a supplementary tool to physical disassembly, the system adopts the Virtual-Object-Simulation teaching approach, combining virtual and physical elements, online and offline methods, and integrating classroom and extracurricular activities to reform existing experimental teaching methods. The practical results demonstrate that the reform of the course not only enhances students' understanding of the oil separator's functional principles, structure, and disassembly procedures, but also improves their knowledge integration and application skills, thereby strengthening both experimental and classroom teaching effectiveness.

## Subject Areas

Industrial Engineering

**Keywords**

Oil Separator, Virtual Disassembly and Assembly (VDA), Experimental Teaching Reform, Three-Dimensional (3D) Model, Neural Radiance Field (NeRF), Unity 3D

## 1. Introduction

With the development of shipping simulation technology, the demand of marine engineering students for virtual simulation system is growing rapidly. Its economic efficiency and interactivity in teaching are far better than real ship equipment. For example, the disassembly and assembly of the oil separator not only requires certain experimental conditions, but also is difficult for intelligent interaction. It may even cause injury due to operation errors. In contrast, the use of virtual simulation system has become an important way to overcome various limitations and cultivate modern ocean engineering talents. Therefore, if an immersive intelligent interactive simulation system for disassembly and assembly of the oil separator can be developed, it will help students to master the functional principle, structure and disassembly operation of the oil separator system, and improve the ability to analyze and solve problems.

The current simulation systems pay more attention to the simulation of equipment and operation process, and ignore its virtual disassembly and installation. Therefore, aiming at the construction of high-precision three-dimensional (3D) equipment model and virtual disassembly system, it is of great research significance to realistically display equipment parts and their virtual disassembly and assembly (VDA), and develop an intelligent interactive 3D VDA system. The VDA system of oil separator is used to simulate the disassembly and assembly operation and daily maintenance of oil separator, which is an important part of marine engineering experiment course.

The key to the realization of immersive teaching and interactive intelligent training platform virtual simulation system is to establish highly realistic 3D equipment and scene models. The traditional methods have high technical requirements for modelers, and the modeling is time-consuming. With the rapid development of 3D reconstruction technology, it has become one of the effective ways to produce virtual 3D models. Especially, there are more and more researches on 3D image reconstruction based on deep learning. It is particularly necessary to use the AI of deep learning to efficiently construct high-quality virtual 3D models. A representative example is the Neural Radiance Fields (NeRF) method proposed by Mildenhall *et al.*, at the International Conference on Computer Vision in Europe in 2020 [1]. NeRF is a 3D image reconstruction technique based on deep learning that has developed rapidly in recent years. It can reconstruct 3D scenes with high quality using only 2D image input, which pushes the application of implicit representation to a new level, and has shown high application potential in image 3D reconstruction [2] [3].

## 2. 3D Virtual Reconstruction of Oil Separator Based on NeRF

In 3D graphics, the viewing direction can be defined by two angular parameters: 1) Azimuth $\theta$: represents the angle between the projection of the viewing direction in the *xy*-plane and the *x*-axis, typically ranging from 0 to 360˚; 2) Elevation angle $\phi$: indicates the angle between the viewing direction and the *xy*-plane, usually ranging from −90˚ to 90˚.

NeRF's working process consists of two main parts: 3D reconstruction and voxel rendering. The core of 3D reconstruction is the continuous scene represented as a 3D point coordinates $p(x,y,z)$ and 2D view direction $d(\theta,\phi)$, which serve as inputs and outputs through a deep neural network to obtain color $c(rgb)$ and voxel density $\sigma$. As shown in Figure 1 below.

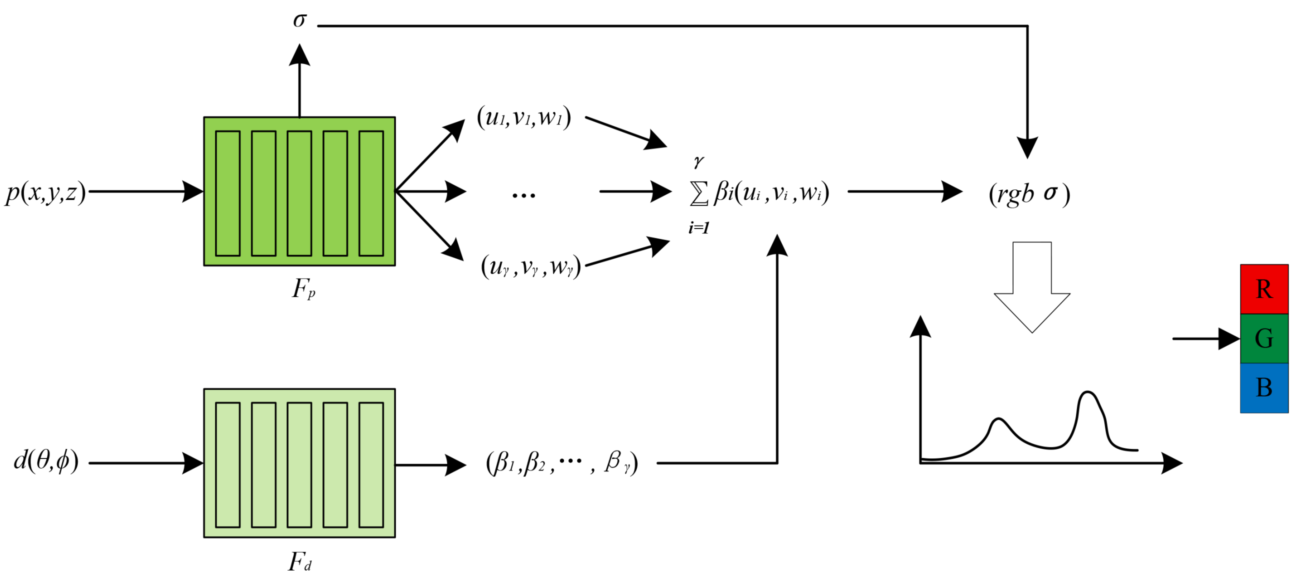


Figure 1. The flowchart of the NeRF algorithm.

Here, the position information is encoded to solve the problem of directly taking the 3D coordinate point position $p(x,y,z)$ and the 2D view direction $d(\theta,\phi)$ as the input of NeRF network, which leads to low rendering resolution. And the input is mapped to high frequency to obtain coordinate coding $\gamma(x)$ and direction coding $\gamma(d)$. Among them, the high-frequency mapping function $\gamma(p)$ is expressed as a sine cosine periodic function as Equation (1):

$$\gamma(p) = \left(sin\left(2^0 \pi p\right), cos\left(2^0 \pi p\right), \cdots, sin\left(2^{L-1} \pi p\right), cos\left(2^{L-1} \pi p\right)\right) \quad (1)$$

where: $\gamma(\cdot)$ is applied to each coordinate value in $x$ and each direction value in $d$ respectively; $p$ is the function input part; $L$ is high-dimensional spatial information.

And in an integral way, denote the color $C(r)$ on the rendering as Equation (2):

$$C(r) = \int_{t_n}^{t_f} T(t)\sigma\left(r(t)\right)c\left(r(t), d(t)\right)dt \quad (2)$$

where: $T(t)$ is the cumulative transmittance along the camera ray from $t_n \sim t$; $\sigma(r(t))$ is the voxel density of the points sampled on the ray $r$. It is calculated as Equation (3):

$$T(t) = \exp\left(\int_{t_n}^{t} \sigma(r(t))\,dt\right) \tag{3}$$

Divide the integral interval $[t_n, t_f]$ of the ray equally $N$, and then randomly sample it in each subinterval. Then the $C(r)$ simplification in Equation (2) is as Equation (4).

$$\hat{C}(r) = \sum_{i=1}^{N} T_i \left(1 - exp\left(-\sigma_i \delta_i\right)\right) c_i \tag{4}$$

where: $T_i$ is the cumulative transmittance; $\sigma_i$ is the voxel density at the sampling point $i$; $\delta_i$ is the distance between the sampling point $i$ and the adjacent sampling point. $\delta_i$, $T_i$ are calculated as Equations (5) & (6):

$$\delta_i = t_{i+1} - t_i \tag{5}$$

$$T_i = exp\left(-\sum_{j=1}^{i-1} \sigma_j \delta_j\right) \tag{6}$$

In terms of specific implementation, NeRF uses a 12-layer fully connected deep neural network to realize the implicit neural representation by optimizing a multilayer perceptron. The specific structure is shown in Figure 2 [4].

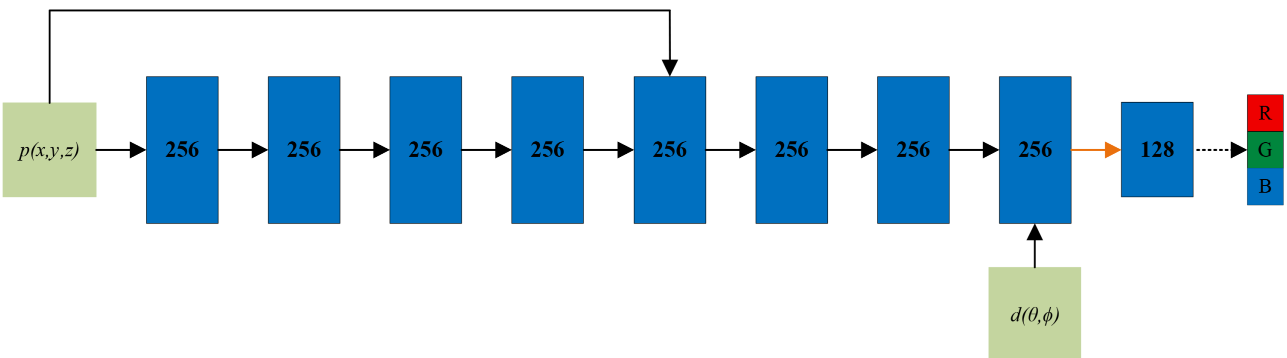


Figure 2. The deep neural network architecture of NeRF algorithm.

All layers in the network shown in Figure 2 are standard fully connected layers, and the numbers within each block represent the dimensions of the vector. The green module is input layer. The blue module is the hidden layer in the middle. The black arrows are the layers activated by the ReLU function. The orange arrows are the layers without the activation function, and the dashed arrows are the layers activated by the Sigmoid function. The 3D coordinates $p(x,y,z)$ input the spatial location signal, transmitted through 8 fully connected ReLU layers with 256 channels each. The network also includes skip connections that connect the network inputs to the fifth layer.

The NeRF deep neural network outputs voxel density $\sigma$ and a 256-dimensional feature vector $(\theta,\phi)$ connected to the positional encoding of the input observation direction. These are then fed into a fully connected ReLU layer with 128 channels for processing. Finally, the Sigmoid activation function outputs the color $c(rgb)$, observed along the direction $d(\theta,\phi)$ at the spatial position $p(x,y,z)$.

When the reconstruction target is a small object, the training set requires several to dozens of images; when the target is a larger object or environment, the training set often needs dozens to hundreds of images. Therefore, around the oil separator body and its components, record a video segment of approximately 1 minute and 51 seconds each, and extract video frames at equal intervals to obtain the training dataset. Due to factors such as camera parameters and human jitter, the clarity of videos or images may be affected. However, NeRF has certain quality requirements for the training dataset, so preliminary screening is necessary.

Therefore, this paper proposes a method for selecting images from the training dataset. The method employs the Laplacian operator [5] to detect edges in test images. It is a second-order derivative-based differential edge detection approach, featuring direction independence and minimal computational complexity. The corresponding mathematical expression is as Equation (7):

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \tag{7}$$

The convolution kernel corresponding to the Laplacian operator is as Equation (8):

$$\nabla^2 f = \begin{pmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{pmatrix} \tag{8}$$

Firstly, perform kernel convolution calculation on the grayscale single channel of the compressed image to be tested with the Laplacian operator, and output the variance. For images with clear boundaries, their variance is relatively large; And images with blurred boundaries have smaller variance, thus obtaining the blur score of the image. A threshold can be set based on the overall blur situation of the training set images to extract a high-resolution training image set. This replaces manual filtering of blurry images and improves the efficiency of image filtering in early datasets. Using Laplace operator to optimize the NeRF reconstruction of the dataset, the peak signal-to-noise ratio (PSNR) and structural similarity (SSIM) indicators were improved by 2.43% and 0.72%, respectively.

Then, 3D reconstruction was performed using an Instant Neural Graph Primitive (Instant NGP) based on the NeRF algorithm [6], which was proposed by MÜLLER T *et al.* [6] as an Instant NGP with multi-resolution hash encoding. It accelerates the training and rendering process of NeRF by several orders of magnitude. And use Instant NGP to remove the redundant 3D reconstruction background generated by NeRF, demonstrating its ability to generate models separately.

This algorithm is written in Python and runs on servers equipped with GPUs. The experimental environment configuration is as follows: the central processing unit is Intel Core i7-7700, with a clock speed of 4.2GHz; The internal/video memory capacity is 16/32GB; the GPU uses 2 NVIDIA 1080Ti chips; The operating system is Ubuntu 16.04. To fully utilize GPU accelerated network training, the system installs CUDA 9.0 and its supporting CUDNN. In addition, OpenCV3.4 has been installed to showcase network detection and classification results. As shown in Table 1 below.

**Table 1.** Configuration Information of the experimental environment.

| Experimental | Configuration parameters |
|---|---|
| GPU | Two NVIDIA 1080Ti |
| CPU | Intel CORE i7-7700, clocked at 4.2G |
| Memory/memo | 16G/32G |
| Operating | Ubuntu 16.04 |
| Compiler | Pycharm |
| Python version | Python 3.9 |
| CUDA version | CUDA 9.0 and its companion |

During the learning and training process of NeRF, the choice of hyperparameters is crucial. For example, the initial learning rate is set to 0.1; And Adam optimization algorithm is selected to obtain an adaptive learning rate for each parameter. L2 loss function is used. Also, batch_size is set to 4096 and 10 rounds are traversed. The specific parameter Settings are shown in Table 2 below. Under this parameter setting, the convergence process of the loss function learned by the NeRF deep neural network is shown in Figure 3 below.

## 3. Implementation of 3D VDA

To achieve the educational reform goal of immersive teaching and interactive intelligent training platform virtual simulation system, taking the typical disassembly and assembly course of marine engine major's marine oil separator system as an example, ALFA-LAVAL P605 marine oil separator, which is the same as the

**Table 2.** The experiment parameters settings.

| Hyperparameters | Parameter values |
|---|---|
| Initial learning | 0.1 |
| batch_size | 4096 |
| Epoch | 10 |
| $\varepsilon$ | 1e−8 |
| $\gamma$ | 8 |
| $\beta_1$ | 0.9 |
| $\beta_2$ | 0.999 |

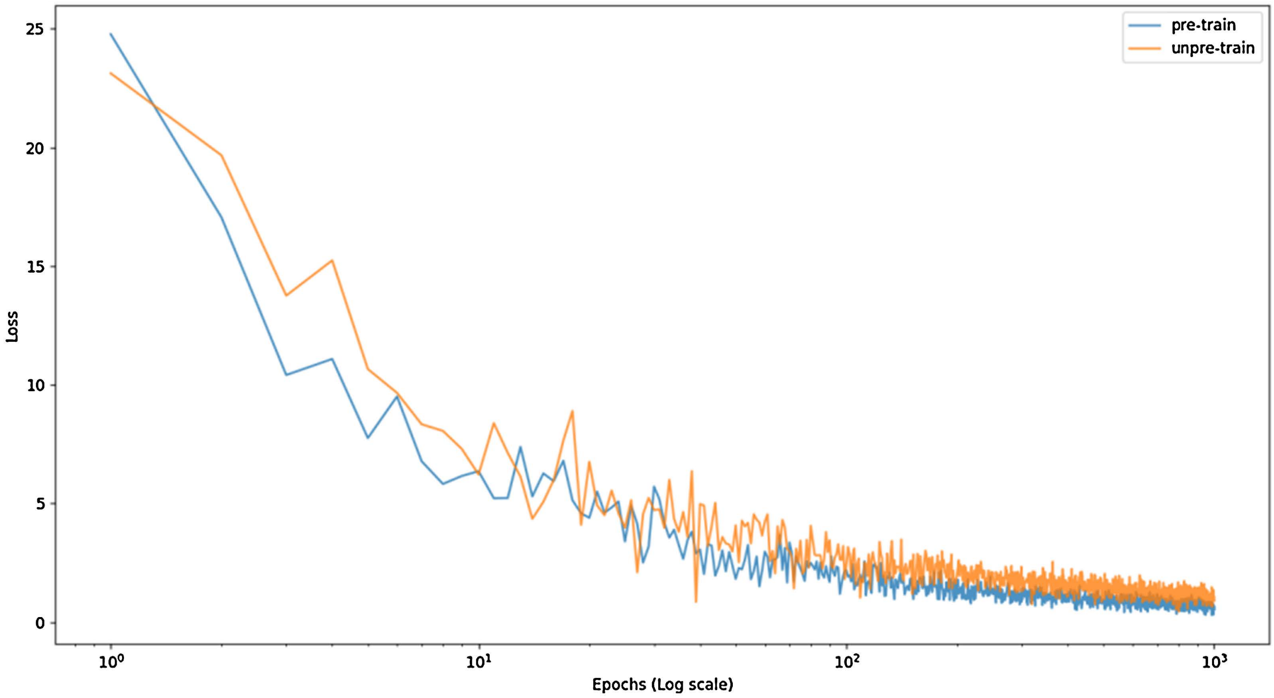


Figure 3. The convergence process of the loss function of NeRF deep neural network under the parameters in Table 3 for pre trained and untrained learning.

undergraduate textbook, is selected as the VDA simulation object. Based on the actual disassembly and assembly process, simulation and virtual reality technology are used to model the corresponding equipment, disassembly tools, and disassembly process 1:1 on the computer, mapping real teaching scenarios, and applying them to classroom auxiliary teaching and disassembly training.

## 3.1. Functional Design

The immersive VDA system of oil dispenser should provide three modes of use: demonstration, exercise and examination. The intelligent interaction includes 3D automatic demonstration, real-time intelligent guidance and explanation of voice, text and animation, intelligent evaluation, analysis and summary.

In demonstration mode, it can be played automatically or manually; In a 3D virtual environment, the system demonstrates the entire process of disassembling and assembling components such as the separation disk, separation cylinder, and vertical shaft of the oil separator, and understand the composition, structure, and assembly relationships of the equipment. In practice mode, there is a prompt function for the operation steps, which allows students to interact with the system through keyboard and mouse operations, thereby performing the disassembly and assembly of components such as the separation plate, separation cylinder, and vertical shaft of the oil separator. In the exam mode, the questioner can set the exam content, time, and whether there are prompts. Students can interact with the system through keyboard and mouse operations to perform the disassembly and assembly of components such as the separation plate, separation cylinder, and vertical shaft of the oil separator. The system automatically records the operation status in the background and provides real-time scoring [7] [8]. As shown in Figure 4.

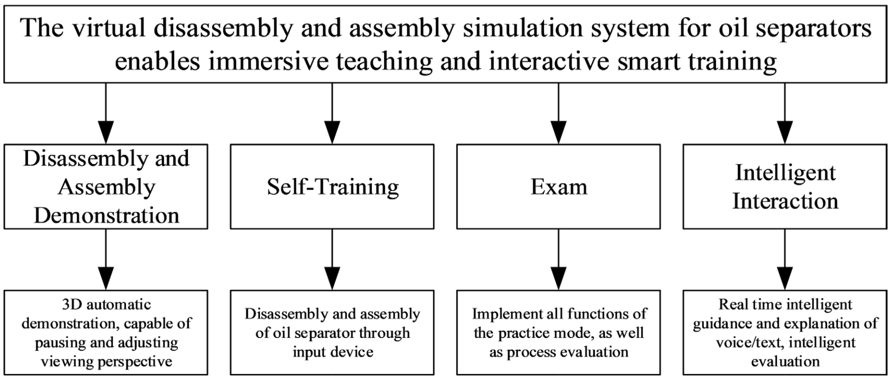


Figure 4. The functions of VDA simulation system for oil separator to realize immersive teaching and interactive intelligent training.

## 3.2. Development Process

The entire development process can be divided into three stages: dataset creation, 3D model construction, and virtual disassembly software design. The virtual disassembly platform is developed using software such as NeRF, Unity3D, VC#, etc. Firstly, collect videos and images to establish a dataset; Secondly, establish a 3D model of the oil separator in NeRF and perform voxel rendering and optimization; Once again, organize the model, clear any unreferenced resources, and export the model as .FBX format file; Then, import the constructed 3D model of the oil separator into the Unity3D development platform and design software for VDA functions; Finally, achieve scene roaming through VC#. As shown in Figure 5. The 3D reconstruction process of some oil separator components is shown in Figure 6.

Finally, based on the virtual reality of Unity 3D, the reasonable arrangement of the space and the action settings of the model were completed for the oil dispenser and the 3D model of the environment. Using various functional nodes and custom script nodes provided by C#, control and implement the disassembly instructions,

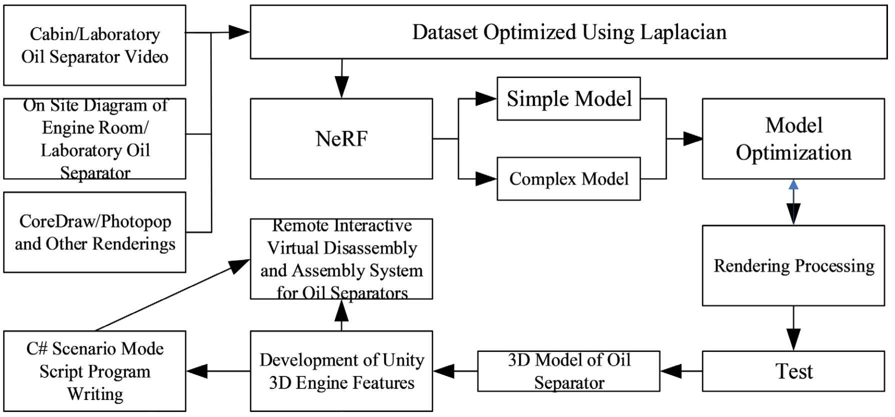


Figure 5. Flow chart of 3D visualization simulation design of VDA system of oil separator.

instructions, and animation demonstration functions of the oil separator model. The animation demonstrating and practicing the VDA simulation system for some oil separators is shown in Figure 7.

The scene adopts 3D real-time rendering technology, which can be operated in real time and rotate 360 degrees. The parts of the disassembly and assembly separator can be turned 360 degrees along the axis, and the scene can also be translated. Among them, the 3D engine visualization mainly includes: 3D virtual scene management, real-time rendering, and 3D pick up, etc.; Physics simulation engine includes collision detection, etc. The script system consists of a script interpreter and its editor. The interface system includes part bar, toolbar, special tool, progress bar, highlight indication and intelligent interactive help system [7] [8].

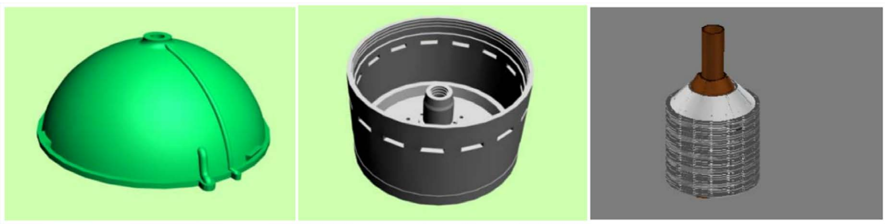

**Figure 6.** The 3D reconstruction examples of the machine cover, separator barrel body and separator of the VDA simulation system of the separator.

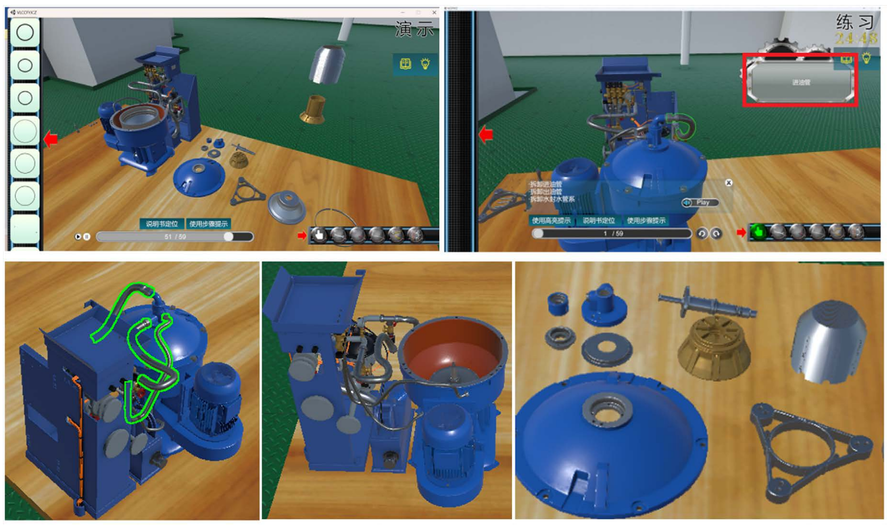


**Figure 7.** The animation function of the VDA simulation system of the oil separator for demonstration and exercise.

### 3.3. Human-Machine Interface Design

The VDA system should have an immersive experience and intelligent interactive human-machine interface. The main design functions include: a main interface for selecting disassembly, assembly, and examination functions, as well as selecting disassembly and assembly components such as the oil separator separation plate, separation cylinder, and vertical shaft; The interface can adapt to displays of various sizes and resolutions, and can also manually set the screen resolution;

The user settings such as shortcut keys, resolution, etc. can be saved; Support human-computer interaction methods such as keyboard and mouse; The interface and scene are navigated using a parts bar, toolbar, specialized tool window, progress bar, component highlight indicator, and intelligent interactive help system. The functions that should be implemented in each disassembly scenario include: 3D views and 3D animations; timing, step counting, scoring; tool selection, use of specialized tools, placement and picking of parts, etc.; disassembly guidance function, including voice prompts, 3D highlight guidance, disassembly error prompts, etc. [7] [8]. As shown in **Figure 8**.

The VDA system for marine oil separators designed for users such as students, trainees, and instructors, which supports expressing operational intentions through keyboard and mouse input. The system determines and executes interactive tasks based on the current scene and input operations, and then provides feedback on the execution results through 3D visualization and animation.


**Figure 8.** The nterface of VDA simulation system for oil separator.

### 3.4. Performance Indicators

The system adopts various optimization techniques to improve scene performance. On a computer equipped with an I7 CPU, 8GB RAM, and 4GB GPU, the scene was opened at a resolution of 1920 * 1080 for comprehensive testing, and no errors or misalignment were observed. The frame rate of the scene exceeds 30 FPS without any frame loss, and the frame rate fluctuation remains within ±2 FPS. The loading and switching of any scene should not exceed 5 seconds. You can choose a windowed/windowless interface; Between image quality and response speed, there are 5 options available, including Fantastic/Beautiful/Good/Simple/Fast/Fastest [7] [8].

## 4. Application and Effect of Experimental Teaching Reform

### 4.1. Application of Educational Reform

The most important role of this virtual disassembly platform is to realize the VDA function of marine oil separator, meet the teaching needs of college students and teachers, and explore the application of teaching reform in combination with the following four aspects [9].

1) Enhance the Connection between Subsequent and Prerequisite Courses

The various components and disassembly knowledge of the oil separator involve basic courses such as "Mechanical Drawing", "Mechanical Principles", "Fluid Mechanics", and are also part of professional courses such as "Marine Auxiliary Machinery". So, in the theoretical teaching of "Marine Auxiliary Machinery" classroom, VDA software can be used to demonstrate and explain disassembly and assembly, so that students can have a deep understanding of the principle and structure of the oil separator. Then, in the experimental teaching of "VDA of Oil Separators", students can further simulate disassembly and assembly by hand, exercise their ability to disassemble and assemble various components of the oil separator, truly master the oil separator equipment, and achieve the goal of coordinating the preceding and following courses.

2) Virtual Software Disassembly

The animation demonstration feature of the VDA software clearly illustrates the disassembly and assembly relationships of the separating disc, separating cylinder, and vertical shaft in a 360-degree animated tour, enhancing students' understanding. The VDA experiment has 4 class hours, serving as the introductory phase to physical disassembly and assembly and also as the first step in combining virtual and real elements online and offline. With the aid of virtual software, students can disassemble and assemble the 3D model of the oil separator online. Moreover, without the constraints of venue and time, students can log in at any time for demonstrations, practice, and simulated exams, fully mastering the 3D structure of the oil separator and its disassembly and assembly process, thereby stimulating their thinking. In the virtual software's demonstration and practice mode, students can gain an in-depth understanding of the disassembly and assembly workflow and the methods for key components.

3) Experimental Design to Enhance Innovation Capacity

As a core experimental course at the undergraduate level, the "Oil Separator Disassembly and Assembly Experiment" is not confined to verification experiments. During the disassembly and assembly process, students are also required to select tools according to the steps, use specialized tools, and proceed step by step to thoroughly explore and measure the assembly and operational relationships of components such as the separator disc, separator drum, and vertical shaft of the oil separator. They are further expected to engage in relevant thinking and analysis based on their acquired professional knowledge.

4) Intelligent Assessment and Fair, Consistent Grading

The assessment for the "Oil Separator Disassembly and Assembly Experiment" was previously conducted through manual scoring at the disassembly site and experimental reports, accounting for 40% and 60% respectively. However, manual process scoring is time-consuming and labor-intensive, lacking fairness and consistency; a single evaluation standard fails to fully reflect individual capabilities, and innovative assessment is even more deficient. By using VDA software, process scoring standards and intelligent evaluation systems can be introduced, or the process can be scored based on the completion files submitted by students; It can provide students with real-time practical scores, which are relatively more fair and consistent.

### 4.2. Intelligent Evaluation Effect and Reliability

In order to verify the reliability and accuracy of the intelligent evaluation of this platform, a comparative experiment was carried out. That is, 20 students from one class were randomly invited from 9 parallel classes, and they were recorded as group A. The physical disassembly and assembly teaching was carried out first, and then the physical disassembly and assembly manual assessment was carried out. Then, 20 students were randomly invited from the other class and marked as group B. After completing the VDA teaching, conduct intelligent scoring and manual assessment scoring for VDA. As shown in **Table 3**, the highest, lowest, and average assessment scores of students in groups A and B are presented in **Table 4**.

The average score of physical disassembly and assembly assessment of group A students was 74.1, and the average scores of intelligent and manual assessment of VDA of group B students were 85.6 and 84.7, respectively. Therefore, the score gap between group A and group B students was nearly 10 points, indicating that the disassembly and assembly level of group B students who underwent VDA teaching was significantly higher than that of group A students who underwent physical disassembly and assembly teaching. The comparison of intelligent and manual assessment scores of group B students in disassembly and assembly assessment is shown in **Figure 9**. The blue line is the intelligent scoring. From the line graph, it can be seen that there is a strong consistency trend between the two sets of data, and the difference is very small, indicating the reliability of the intelligent scoring method of the platform, which can be used for practical assessment [10].

### 4.3. Platform Usage Survey and Evaluation Analysis

For the virtual oil separator equipment of this platform, perform the disassembly

**Table 3.** The scoring results for each group.

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group A manual | 62 | 86 | 74 | 66 | 65 | 71 | 70 | 61 | 85 | 67 | 76 | 82 | 86 | 82 | 70 | 64 | 72 | 81 | 78 | 84 |
| Group B Intelligence | 85 | 77 | 83 | 88 | 83 | 98 | 81 | 79 | 85 | 90 | 82 | 86 | 84 | 85 | 93 | 85 | 88 | 90 | 89 | 81 |
| Group B Artificial | 80 | 78 | 87 | 87 | 83 | 92 | 83 | 76 | 81 | 89 | 83 | 87 | 80 | 83 | 90 | 86 | 85 | 92 | 87 | 85 |

**Table 4.** The statistics of the highest, lowest and average assessment scores of the experimental group.

| Type of score | Group A manual scoring | Group B scored intelligently | Group B scored manually |
|---|---|---|---|
| Maximum | 86 | 98 | 92 |
| Minimum | 61 | 77 | 76 |
| Average | 74.1 | 85.6 | 84.7 |

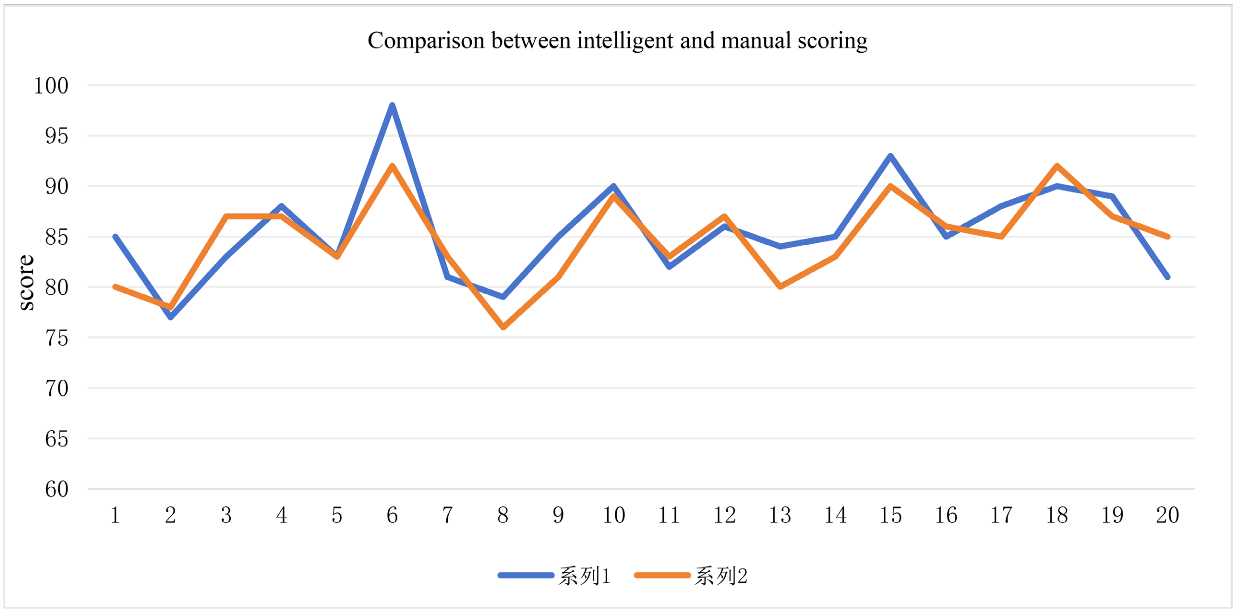


**Figure 9.** The line chart of the comparison of intelligent assessment scores and manual assessment scores of group B students.

and assembly demonstration and practice process of the separation disc, separation cylinder and vertical shaft, execute all software functions and record them. Emphasis is placed on conducting classification testing and analysis of software functionality integrity, scene experience, intelligent and accurate interaction, response latency, stability of operation and performance, intelligent scoring performance, and platform bugs. Secondly, for traditional VDA software, its sense of tranquility and intelligent interaction are still insufficient, so it is important to focus on testing the user experience and interactive intelligence of this platform; Providing students with a good user experience is also very important.

The summary of test results, as shown in Table 5. The performance of various testing indicators on this platform has achieved or reached a usable level. There is a certain reflection and improvement in both the experience of tranquility and the interaction of wisdom.

Finally, a questionnaire was conducted among students who had used the VDA software. The survey primarily covered aspects such as the difficulty of software usage, user comfort, student acceptance, and scientific validity.

For the investigation of the scientific rationality of VDA software, the questionnaire used quantitative indicators: 0 points for completely unreasonable, 1 point for individual unreasonable, 2 points for basically reasonable, and 3 points for completely reasonable. As shown in Figure 10, the bar chart generated for the survey result data. In general, the vast majority of students who use the software believe that the scientific nature of this virtual disassembly software is reasonable.

Regarding the difficulty, comfort, and student acceptance of using this software, the survey questionnaire is set to: difficult 0 points, relatively difficult 1 point, relatively easy 2 points, and very easy 3 points. As shown in Figure 11, a bar chart is generated for the survey result data. In terms of difficulty, comfort, and user

**Table 5.** The summary of test results.

| Test No. | Test content | Test results |
|---|---|---|
| 1 | The function of disassembling and assembling operation of the separator | Implementation |
| 2 | The function of disassembly and assembly operation of the separator cylinder | Realization |
| 3 | The function of disassembly and assembly of the vertical shaft of the oil separator | Realization |
| 4 | Reminders and use of common tools | Normal |
| 5 | Remind with the use of special tools | Normal |
| 6 | The stability of the virtual simulation platform | Stability |
| 7 | 3D scene refresh with or without delay | No |
| 8 | Smart voice interaction | Good |
| 9 | Wisdom Highlighting tips | All have |
| 10 | Comparison of intelligent scoring and manual scoring | Consistency |

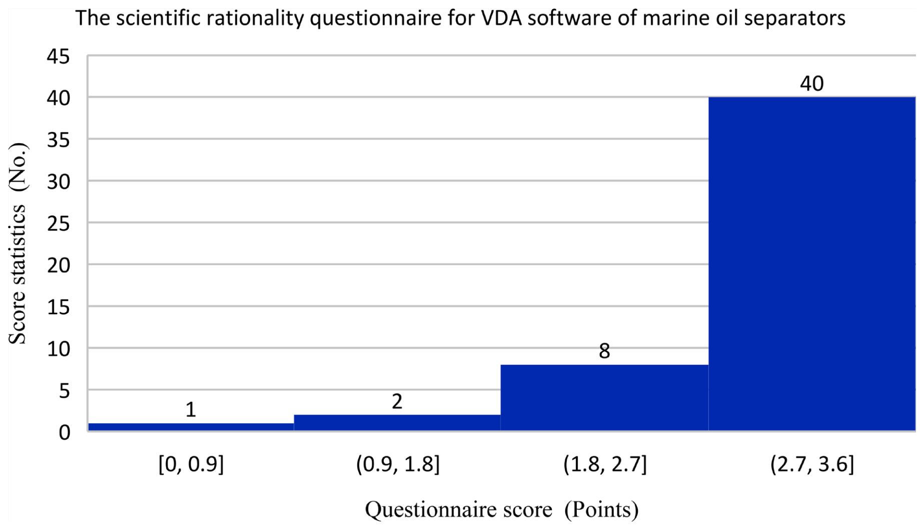


**Figure 10.** The scientific rationality questionnaire for VDA software of marine oil separators.

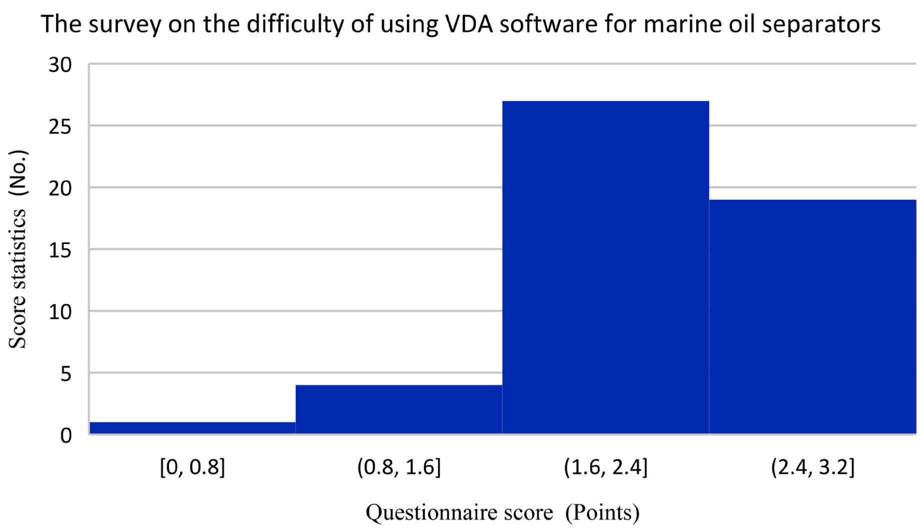


**Figure 11.** The survey on the difficulty of using VDA software for marine oil separators.

acceptance, the vast majority of students who participated in the use were able to experience this virtual disassembly software well; But there are also a few students who cannot proficiently use the various functions of this software, which also suggests that the VDA software can be further improved and the demonstration function can be strengthened.

### 4.4. The Effectiveness of Educational Reform

A survey was conducted on the effectiveness of software usage for the educational reform application of "disassembly and assembly experiment of oil separator". The survey targets students and teachers who use the software. The survey mainly includes: the teaching effectiveness of VDA, students' mastery of the content, interest and recognition of VDA teaching; the initiative of preview before class and active learning during class; and the ability to solve problems, emotional experience, etc. From the analysis of the result data, it can be seen that the VDA teaching of the "oil separator disassembly experiment" has achieved significant results. The specific results and feedback of the educational reform are as follows:

1) Examination results

The precise adjustment of class hours and the process assessment of VDA software for oil separators focus on the comprehensive improvement of students' abilities, improve the assessment and evaluation standards for students, fully test their hands-on and thinking abilities, and receive good feedback from students.

The virtual software is used to compare with the actual teaching of oil separator disassembly and assembly, and the effect is shown in **Figure 12**. It can be seen that after using the VDA software teaching, the excellent rate of actual examination results is greatly improved, breaking through the normal distribution law, and the average score is also significantly improved. This is mainly due to the VDA software can ardently interest students, ensure the safety of students, and can practice at any time, without considering the maintenance of equipment, infinite repetition, so that the actual training time is significantly increased. Many students practice to practice can make perfect, and even can be completed within ten minutes. Therefore, the intelligent scoring and teacher scoring of virtual system disassembly and assembly have been significantly improved [11].

2) Interest and identification

Ninety-five percent of the respondents said they liked the teaching method and atmosphere of VDA. In the learning process, it can not only improve the practical ability, but also obtain a greater sense of satisfaction and happiness when it is recognized by the software intelligent rating, thus enhancing the interest and confidence in learning.

In the exploration of curriculum reform, the students all said that the teaching reform of the "oil separator disassembly and assembly experiment" course combined reality with virtual reality, which made them have a deeper understanding of the oil separator disassembly and assembly. The combination of virtual and real teaching in "VOS" (Virtual-Object-Simulation) allows students to gradually identify, analyze,

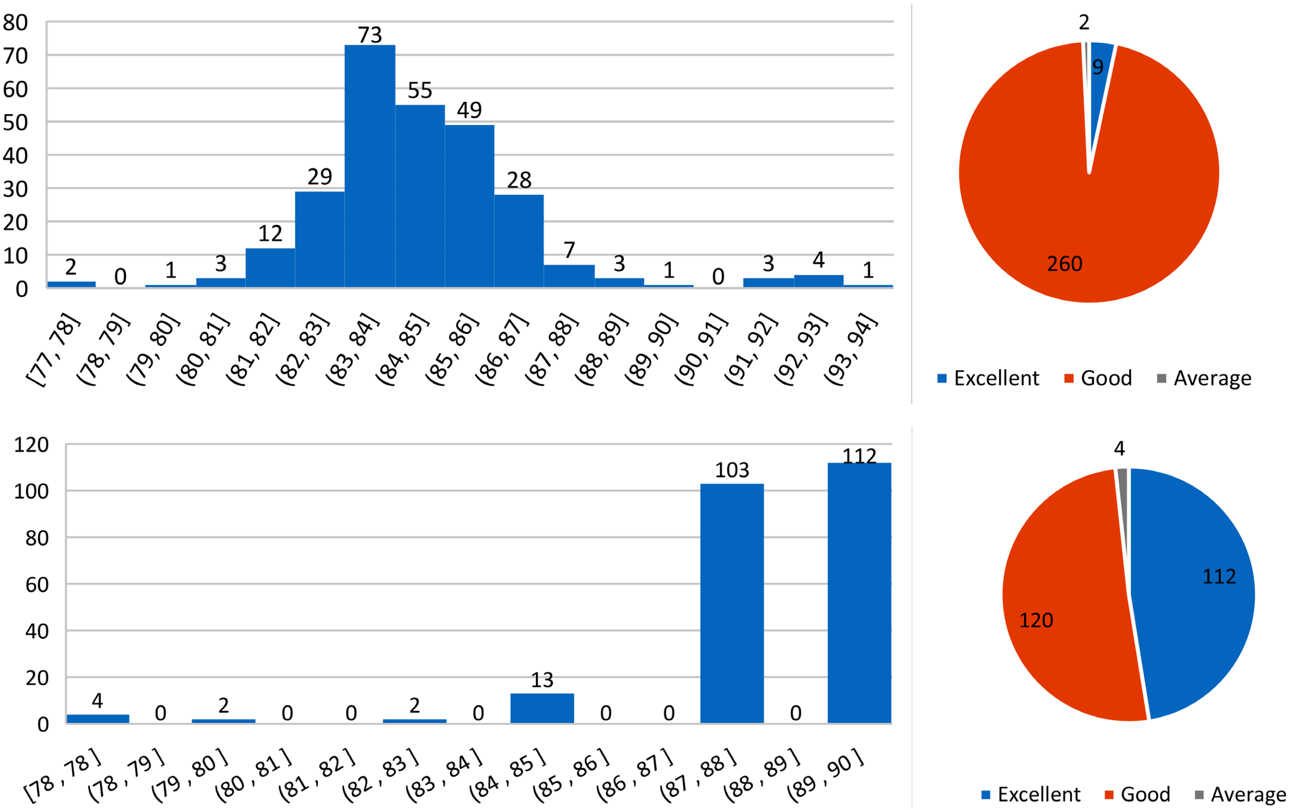


**Figure 12.** The comparison of actual test scores before and after using VDA software for teaching.

and study issues related to the disassembly and assembly of oil separators from virtual software disassembly and assembly to physical disassembly and assembly, and grasp the disassembly and assembly of oil separators from multiple perspectives [12].

3) The subjective initiative

Due to their interest in virtual 3D software, students' subjective initiative in learning has significantly improved compared to before the implementation of VDA education reform. In various stages such as pre class preparation, in class learning, and post class exercises, students are generally able to exert their autonomy and actively participate in each process.

The "VOS" virtual real combination teaching method requires students to comprehensively apply the knowledge learned from multiple professional courses such as "Ship Auxiliary Machinery", "Mechanical Drawing", "Mechanical Principles", and "Fluid Mechanics" to virtual disassembly, observation, and analysis, cultivate students' ability to solve practical engineering problems, and promote the application of professional knowledge in pre- and post courses.

4) The creative thinking

In the implementation process of VDA teaching, an active atmosphere of discussion and communication is also formed, which deeps students' thinking, generates a spark of wisdom in the collision, and in some cases triggers associations and imagination, thus producing creative thinking beyond traditional classroom teaching.

The VDA software of oil separator stimulated students' curiosity and opened up new ideas for them. In 33 students surveyed, 27 people from separation plate, bowl to every component in the process of disassembly and assembly of vertical structure parameters show curiosity and shape characteristics. Virtual animation experiment to study the structure of each component and shape provides the opportunity to satisfy their thirst for knowledge [11]-[13].

In summary, the VDA software has achieved good results in the teaching reform of "oil separator disassembly and assembly experiment", which improves students 'mastery of oil separator disassembly and assembly. It greatly enhances students' interest and innovative thinking, and cultivates their professional ability for course objectives and future work.

## 5. Conclusions

This paper discusses the teaching reform method of combining virtual and reality in the course of "oil separator disassembly and assembly experiment". The results show that the teaching reform method can help students deepen the understanding of the functional principle, structure and disassembly of the oil separator, and fully exercise their comprehensive ability. The adjustment of intelligent scoring comprehensively tested students' ability. The "VOS" teaching method based on the combination of reality and virtual enables students to not only understand the principles and structures, but also to show a clear interest in exploring complex engineering problems.

The developed system can be used for immersive VDA demonstrations of oil separators, intelligent interactive exercises and exams, as well as intelligent scoring, which is conducive to improving the training and theoretical teaching conditions, reforming teaching methods, updating teaching content, improving teaching level, and breaking through the boundaries of existing theoretical and practical courses. Expected to save teaching costs, increase teaching design, interest, and innovation; At the same time, it also stimulates students' innovative thinking and interest. We will promote its application in professional courses and practical training departments, continuously improve it, and enhance its reference value and application prospects.

Although the VDA can to some extent solve some problems in practical disassembly and assembly, students lack tactile perception of mechanical equipment and control of disassembly force, which is also a disadvantage faced by virtual disassembly and assembly.

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## Conflicts of Interest

The authors declare no conflicts of interest.

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