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Research on the Construction of Virtual Simulation Training System for Intelligent Operation and Maintenance of Logistics Machinery and Supply Chain Risk Early Warning under the Background of Industry-Education Integration--Taking the Reform of Practical Teaching of Supply Chain Management Specialty in Higher Vocational Colleges as an Example

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SUMMARY: *Aiming at the deficiencies in the practical teaching scene of supply chain management majors in higher vocational colleges and universities, this paper proposes a scene creation method based on the integration of industry and education and virtual simulation. Virtual simulation from the logistics machinery intelligent operation and maintenance and supply chain risk early warning two aspects to realize. Among them, the intelligent operation and maintenance system of logistics machinery is constructed by using Omniverse and Isaac Sim, and the simulation of supply chain risk early warning is realized by changing parameters in a relatively stable supply chain system. The research finally creates practical training teaching scenarios based on MR and VR technologies for the reform of supply chain management professional practice teaching in higher vocational colleges. When the intelligent operation and maintenance system of logistics machinery designed in this paper carries out virtual simulation actions, the delay time of the actions is less than 2s, and the detection accuracy of the supply chain risk early warning system is above 90%. Students' acceptance of practical training teaching based on industry-teaching fusion and virtual simulation is high, and this teaching mode can not only better meet the requirements of skill development, but also promote the reform of supply chain management professional practice teaching in higher vocational colleges and universities to a certain extent.*

KEYWORDS: *Industry-teaching integration; virtual simulation; intelligent operation and maintenance of logistics machinery; supply chain risk early warning; teaching reform*

1 Introduction

The current mode of competition in the world business has been transformed from the traditional competition between enterprises to the competition between supply chain and supply chain [1]. This transformation highlights the important position of supply chain in the whole economic system. With the rapid development of digital and intelligent technology and the deepening trend of globalization, the logistics industry and supply chain management have ushered in unprecedented development opportunities. The application of digital and intelligent technology has brought the possibility of more refinement and intelligence to the logistics

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industry and supply chain management, which has greatly improved the efficiency of resource allocation and the quality of logistics services [2-4]. At the same time, the deepening trend of globalization also makes it necessary for enterprises to search for high-quality resources on a global scale in order to meet customer demands [5, 6]. In this context, the importance of the supply chain management profession as a discipline that studies how to optimize resource allocation, improve the efficiency of intelligent operation and maintenance in the logistics industry, promote early warning of supply chain risks, and reduce costs has become more and more prominent.

Technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) have provided greater accuracy in the operation and maintenance of smart warehouses, robots, self-driving vehicles and other machinery and equipment in the logistics industry, as well as improved the response time for supply chain risk warnings. Celestin [7] used AI, IoT, and machine learning (ML) algorithms for predictive maintenance of logistics fleets to reduce fleet maintenance costs, downtime, and equipment failures by 40%, 50%, and 60%, respectively. Ohuei and Aji [8] found that AI-based predictive maintenance for robots reduces unplanned downtime and maintenance costs and extends robot service life and real-time robot detection and automated response with technologies such as IoT sensors, ML and computerized maintenance management systems. Khmara [9] leverages the data processing and predictive analytics advantages of AI technology to optimize the efficiency of warehouse operations by analyzing and predicting seasonal consumer demand, reducing the risk of out-of-stocks or backlogs, and combining it with computer vision technology to detect the status of goods to improve the efficiency of the operation and maintenance of smart warehouses. Mu [10] analyzed a variety of risks such as environment, management, operation and customs clearance in each link of cross-border e-commerce logistics supply chain through Bayesian model, and constructed a risk early warning model to provide support for enterprises to identify risks and prevent and control strategy development. Huang [11] integrated five DL algorithms for processing and fusion of heterogeneous data from multiple sources in the supply chain and developed an AI-based early warning system for supply chain risk, which reduced risk loss and disruption frequency by 35% and 28%, respectively, and improved response speed by 40% compared to a single algorithm. Feng et al [12] used particle swarm optimization algorithm to dynamically adjust convolutional neural networks and introduced advanced encryption standards to build a distributed early warning system for logistics supply chain security risks, with response time reduced to 95 ms and the risk of data leakage reduced to 10% when combined with federated learning.

In addition, the schooling concept of industry-teaching integration also provides strong support for the practical teaching of supply chain management majors, and the close cooperation between local colleges and universities and the business community, which places students in the industry, can realize the optimal allocation of educational resources and industrial resources, and enhance the relevance, effectiveness and professional practice skills of talent cultivation [13, 14]. This cooperation model not only helps to solve the current shortage of supply chain talents, but also lays a solid foundation for the sustainable development of the supply chain industry in the future. Under the background of industry-education integration, the virtual simulation training model has set off a boom in the field of education. The virtual laboratory hosted by the University of Oregon in the United States has dozens of virtual experiments, including energy and environment, mechanics, thermology, astrophysics, etc [15]. The virtual simulation experimental teaching platform developed by Beijing Obier Software Technology Development Co., Ltd. adopts the hybrid architecture mode of B/S+C/S, covering a number of professional fields such as engineering mechanics and other specialized simulation teaching platforms such as experiments, practical training, production internships, semi-physical simulation factories, etc. [16].

And the development of digital technologies such as Virtual Reality (VR), Augmented Reality (AR), IoT, Digital Twin (DT), and tools such as Unity provide a more cost-effective and productive model of hands-on Virtual Simulation (VS) training for practical teaching. Yan et al [17] developed a VS teaching platform using DT technology, which fully integrates virtual and physical elements to create a real-time interactive practical teaching mode for students, assisting them in understanding theoretical knowledge and cultivating their innovation ability. Barosan et al [18] created a VS environment for distribution centers based on modeling tools such as Unity and a DT model of a self-driving truck, which allows designers to simulate and test different driving scenarios to optimize truck distribution performance. Li et al [19] created a 3D-VS experimental teaching platform based on IoT technology that brings together modes such as games, competitions, breakthroughs, explorations, and flipped experiments to enable students to improve their practical and innovative skills in an immersive environment. Gao et al [20] used IoT information technology to simulate and analyze the supply chain risk management system, sort out internal and external risks, and use RFID, GPS and other technologies to manage risks as a way to improve supply chain informatization.

The current status of VS practical training in the logistics industry and supply chain management teaching. Qu et al. [21] opened a VR-based practical teaching system for automated guided vehicles in supply chain education and set up a “cognitive-operational-collaborative” teaching process, which integrates a variety of logistics training environments to create an immersive and realistic training atmosphere for students. Wang [22] applied VS experiments in the teaching of logistics system planning and design, through modeling and simulation of the logistics system, to find the system problems and put forward the system optimization strategy in a targeted way, to maintain the stability of the logistics supply chain system, and to improve the effect of talent cultivation. Wang et al [23] introduced the green logistics VS experimental course, which is based on the hybrid teaching mode of school-enterprise cooperation + online and offline integration, and promotes the practical training of logistics courses to realize low-risk, low-cost, and high-efficiency. In order to innovate the teaching practice of warehouse management course in logistics supply chain, He [24] designed the teaching mode of “task release-practice teaching-autonomous practice-timely assessment” based on VR simulation, which promotes the efficiency and quality of students' skill training. Pan et al [25] established an integrated platform for logistics VS teaching system to realize an interdisciplinary, multi-stage, school and course internal and external practice curriculum system in the context of industry-education integration through VR integration and innovation drive. Mao et al. [26] studied the VS experimental teaching platform of China Railway Express Logistics Operation, which demonstrated the logistics operation process along the “Belt and Road” for students and experienced the whole process of international multimodal transportation. Ye [27] designed a supply chain operations management simulation software, students through the form of the game combined with the theoretical knowledge of supply chain management and practical operation, dynamic and repeated practice for students to provide overall training conditions. Pacheco-Velazquez et al [28] developed a logistics simulation tool integrating integrated technology, data analysis, and strategic operations, which not only provides a safe practical training space for logistics education, but also assists enterprises to customize their wind control, operational planning, and decision making. The continuous maturity of VS system provides support for logistics and supply chain management teaching, but logistics machinery transportation and supply chain risk early warning, as an important content in logistics and supply chain management, have not effectively opened VS teaching system.

In order to give full play to the role of virtual simulation technology in the cultivation of vocational ability, the study firstly established a virtual simulation training system containing “three categories, two systems and five combinations”, in which the “two systems” include the intelligent operation and maintenance simulation system of logistics machinery The “two systems” include intelligent operation and maintenance simulation system of logistics machinery and supply chain risk early warning simulation system. After that, MR and VR technologies are utilized to design virtual simulation teaching scenarios for teaching practice, so as to enhance students' supply chain management professional knowledge in the form of virtual reality. Finally, the design effect of the two systems is verified through simulation test, and the effect of teaching reform is explored through satisfaction survey and teaching evaluation.

2 Construction of a virtual simulation training system

The construction of virtual simulation training system is conducive to enhancing the relevant skills of supply chain management students in higher vocational colleges and universities, while the students' perception of intelligent operation of logistics machinery and supply chain risk is the top priority of practical teaching. In this regard, this paper builds a virtual simulation training system for supply chain management professional practice teaching from two aspects of intelligent operation and maintenance of logistics machinery and supply chain risk early warning.

2.1 Overall structure of virtual simulation training system

Based on the logistics business workflow and typical work projects, according to the students' cognitive law, combined with the supply chain management course system, synchronized with technological innovation and development, the establishment of the “three categories, two systems, five combinations” of virtual simulation training teaching system shown in Figure 1.

(1) Three categories

In arranging virtual training projects, follow the cognitive laws of students, in accordance with the principle of easy to difficult, the virtual simulation of real training projects are divided into three categories: basic practical training, improvement of practical training and innovative practical training, and progressive arrangement of practical training projects. Basic practical training is the most intuitive, easy to start the project, focusing on exercising the ability of students to operate logistics simulation facilities and equipment, such as the operation of forklift simulation driving system. Improve the class of practical training using virtual reality technology to simulate the actual scene of the logistics enterprise operations, simulating the job workflow and the operation of the links, students to multi-role interaction to participate in the completion of the virtual work tasks, through the post of a variety of different abnormal operations to more deeply grasp the skills of the position. Innovative practical training requires students to comprehensively utilize the content of basic and enhanced practical training to creatively design innovative logistics planning system and warehouse planning system.

(2) Two systems

The “two systems” is based on the supply chain management professional training program, combined with the talent training objectives, according to the professional knowledge system and the practice of law, the establishment of logistics machinery intelligent operation and maintenance and supply chain risk early warning of two simulation systems of virtual training.

(3) Five combinations

The “five combinations” refer to the combination of virtual simulation training with theoretical courses, with physical training, with scientific research results, with actual projects, and with work business.

Combination of virtual simulation training with theoretical courses: 2 virtual simulation training are effectively combined with corresponding theoretical courses, covering 14 major courses of logistics management. Combination of virtual simulation training and physical training: each virtual simulation project does not exist independently and operate independently, they are complementary and mutually reinforcing with 5 physical training courses, which can favorably promote the effect of practical training. Virtual simulation of real training and research results: through the school, logistics enterprises, virtual simulation software companies to jointly develop virtual training course resources, the real-time introduction of advanced logistics technology, and logistics research results to keep pace. Combination of virtual simulation training and actual projects: the representative actual projects of famous enterprises are transformed into virtual training projects, allowing students to play the role of employees of famous enterprises and complete the projects in real time, deepening their understanding of the work tasks and the image of famous logistics enterprises, and strengthening students' sense of identity with the logistics management profession and the school-enterprise cooperation enterprises. Combination of virtual simulation training and work business: the design of the virtual training project originates from the work business of the logistics enterprise positions, students carry out virtual training projects at the same time, is also the process of rehearsal of the actual work business of the positions, through the practice, the students can have a more intuitive understanding of the logistics positions, the top internship on the job more quickly.

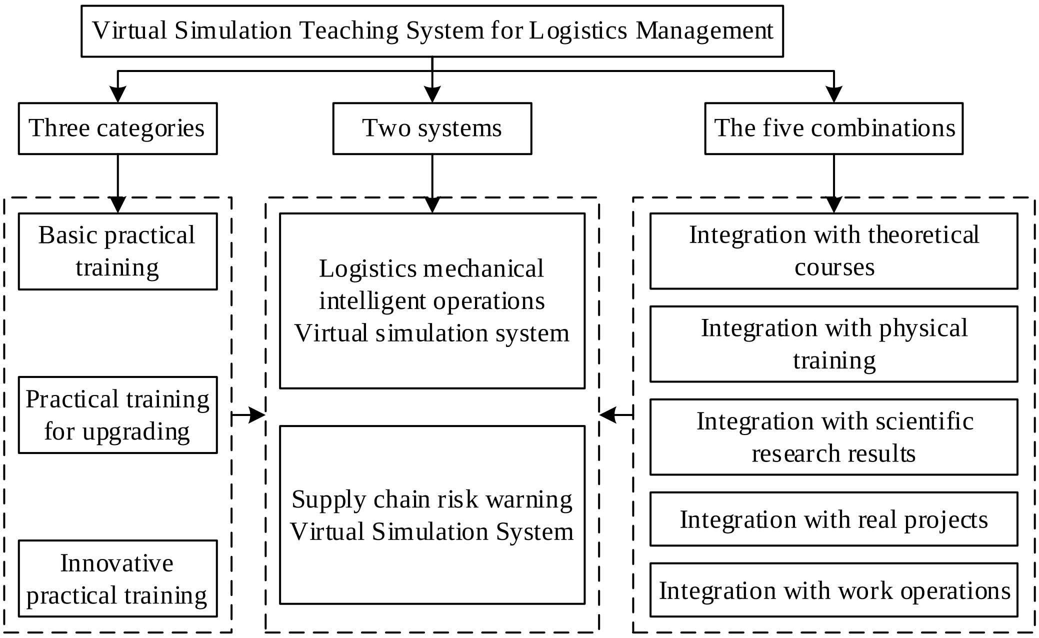

Figure 1: Virtual simulation practice teaching system

2.2 Logistics machinery intelligent operation and maintenance simulation system design

This paper builds a simulation system for intelligent operation and maintenance of logistics machinery based on Omniverse and Isaac Sim. The use of Omniverse and Isaac Sim is mainly to use its high-performance, realistic 3D graphic rendering and physics engine to realize the image of courier sorting simulation and access to realistic courier datasets.

Omniverse is a new generation of scalable simulation environment platform developed by

NVIDIA for virtual collaboration and real-time, realistic and accurate simulation, which consists of five major components, namely Nucleus, Connect, Kit, Simulation and RTX Renderer, to achieve maximum flexibility and scalability. The main functions of each component are as follows:

(1) Nucleus core service, which can be regarded as a private cloud that can store 3D content, is used to handle user authentication, collaboration services, and data storage.

(2) Kit suite is the backbone of all applications and is used to develop a robust application framework based on a clean workflow.

(3) The Connect connector allows users to fully integrate external DCC applications into the Omniverse platform.

(4) RTX Render provides scalable and accurate ray tracing and route tracing rendering.

(5) Simulation delivers high-quality, real-world physics simulations.

Isaac Sim is a robotics simulation toolkit built on the Omniverse platform, which utilizes the powerful technology of the Omniverse platform with essential features for building realistic virtual robotics worlds and experiments. With Isaac Sim's powerful physics engine, realistic rendering, and rich sensors, researchers can use it to create powerful, physically accurate simulations and synthesize datasets that are nearly identical to real data to train and test robots more efficiently, simulating realistic interactions between robots and their designated environments, which saves on upfront development and experimentation costs. The Isaac Sim build principle is shown in Figure 2.

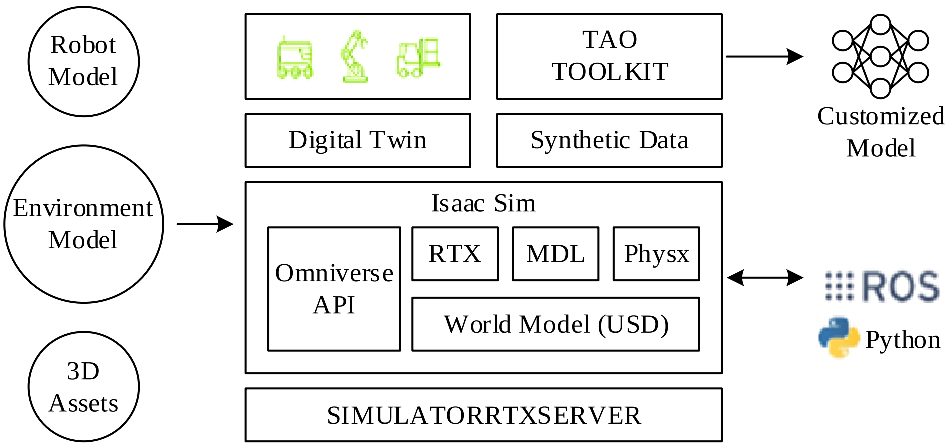

Figure 2: Isaac Sim architecture

When building the logistics machinery intelligent operation and maintenance simulation system, we first create a default venue environment in Isaac Sim. This site environment integrates the properties of the real physical world, such as rigid body, collision, gravity, friction, etc., which can better simulate the physical phenomena in the real scene. Multiple Plane modules are created to build the sorting platform, and in order to fully reflect the actual sorting platform scenario, reference is made to the commonly used gimbaled honeycomb module, and each Plane module is given a corresponding honeycomb module material map, and each module is set strictly in accordance with the aspect ratio of the map to prevent the honeycomb module appearance from deformation phenomena. Finally, a 4.6m×2.8m express delivery sorting simulation platform was built, and two entrances and six exits were set up to simulate multiple entrances and multiple exits of the express delivery sorting scene.

The three-dimensional model of the courier box was produced using 3dMax. In 3dMax, the six faces of the model are set as separable polygons, so that it is easy to give each face the corresponding texture and material. After the courier model was drawn, it was exported to the USD file format and imported into the Nucleus asset in Omniverse for use in Isaac Sim. All six sides of the courier box use the stickers of the SF Express box as the material, and in order to make the effect of the courier box more realistic, sticker effects such as tape and express order barcode are also added to some of the courier boxes.

The relationship between the camera parameters of the simulation environment and the internal parameters of the camera is as follows:

$$f_x = \frac{H \cdot f}{Vertical\_Aperture} \tag{1}$$

$$f_y = \frac{W \cdot f}{Horizontal\_Aperture} \tag{2}$$

where f is the physical focal length of the camera, f_x and f_y represent the normalized focal lengths of the x-axis and the y-axis of the image coordinate system, H, W represent the height and the width of the image, respectively, and $Vertical\_Aperture$ represents the vertical aperture of the camera, $Horizontal\_Aperture$ represents the horizontal aperture of the camera. By setting these parameters, the camera can be set to any camera internal reference.

The process of building the intelligent operation and maintenance simulation system for logistics machinery is shown in Figure 3.

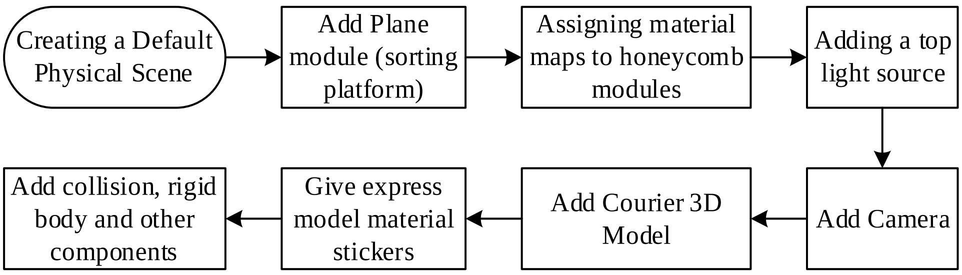

Figure 3: Simulation system setup process

2.3 Supply chain risk early warning simulation system design

Supply chain risk early warning is in a relatively stable supply chain system, change a certain or several parameters, the entire supply chain for system stability analysis, if the system can maintain stability, or in a short period of time after the system adjustment to restore stability, the system is more stable, can withstand a certain degree of risk, if the change of parameters, the system in some parts of the system can not be converged, but rather to the direction of the diffusion of the paradox of the actual direction, the then the whole logistics system will be paralyzed. A typical supply chain system and possible risk elements are shown in Figure 4. The system contains many links, and the subsystems are interlocked like a chain.

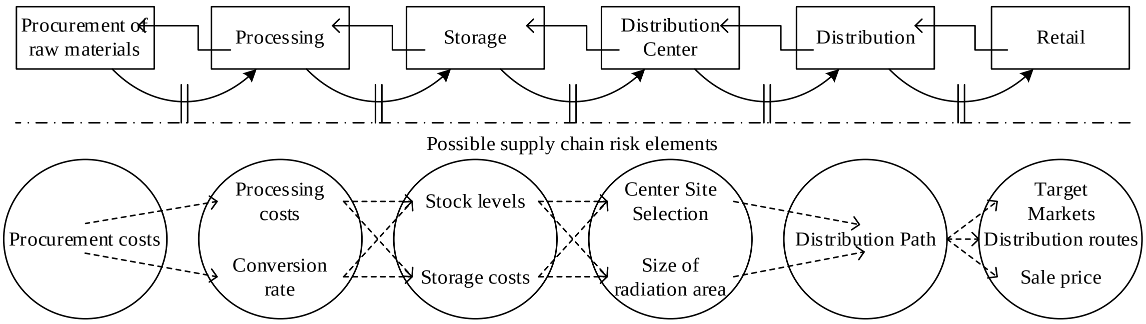

Figure 4: Typical supply chain systems and possible risk factors

When carrying out supply chain risk identification and system diagnosis, it is first necessary to identify the risk elements and recognize which elements are risk elements, such as inventory levels, selling prices, costs, etc., and then carry out system stability detection through the adjustment of these risk elements in order to explore the potential risks faced by the system. The identification and detection of risks can often be judged through sensitivity analysis or rely on objective statistical analysis to discover the extent of risk damage and its regularity. In reality, there are often changes in some supply chain elements, and once there is a large change in some parameters, or a small change in some key elements, it may lead to a disruption in the articulation of the whole system and disruption risks, etc.

Once the risk elements are identified, the second step requires the determination of detection elements and diagnostic elements, that is, after the change of risk elements, what kind of change trend will occur in detection elements, and what kind of trend can be diagnosed as system paralysis.

Based on the above analysis, using the relevant tools for assistance, a common supply chain system can be established, the system is mainly composed of inventory, sales price, demand, procurement, cost, forming 2 circular systems, namely:

(1) Inventory quantity - Inventory cost (total cost) - Purchase quantity - Inventory quantity

(2) Inventory quantity - Selling price - Demand quantity - Inventory quantity

The whole system is divided into three modules, i.e. Supply Chain Module, Diagnostic Module and Inspection Module. The initial supply chain system overall operation is stable, in order to detect the ability of the system to resist risks, the diagnostic module is added to the system, that is, to carry out the changes in demand, inventory changes and unit costs, and then the detection module to carry out the corresponding detection, in order to carry out the system detection, it is necessary to select the detection parameters, and the system has been selected to detect the changes in the sales price. A stable system, the price changes with the size of the inventory, the size of the demand, etc., under normal circumstances, the price should fluctuate within a certain range, therefore, you can take the range of price changes as a specific detection parameter, the stability of the entire supply chain system for the stability test, once the range of price changes exceed a certain value, it can be diagnosed as system paralysis, the entire system can not continue to operate, if the value in the If the price fluctuates within the range of this value, or returns to the level of normal fluctuation amplitude after short-term self-adjustment, the system can be regarded as more stable.

3 Creation of practical training teaching scenarios based on industry-education integration and virtual simulation

With the help of industry-education integration, the method of creating scenarios is developed with virtual simulation training centers and practical training sites as the main carriers. Guided by OBE, we start from the employment positions of senior supply chain management majors, identify the key skills required for each position, and then refine the macro and micro scenarios required for the development of key skills. We cooperate with industrial enterprises and software development enterprises in terms of job analysis and skill analysis, and use virtual simulation as a tool to design and create the key elements of skill development scenarios, and form a systematic scenario library that can be freely invoked.

The method of creating scene elements based on virtual simulation mainly includes:

(1) Using MR mixed reality technology to create hands-on simulation scene elements. Through MR technology, students were able to explore the impact of different warehouse planning scenarios on the operational efficiency and cost of distribution centers. In this session, students were first required to collect and analyze a variety of data on the operational aspects of the site, including the time, efficiency, and error rate of storage, picking, and sorting operations. Then, they use the MR system to create a variety of different warehouse planning scenarios and evaluate their impact on the operational efficiency and cost of the distribution center by simulating the performance of these scenarios in actual operations. Students can view and manipulate these scenarios in 3D virtual reality through the MR system. For example, they can see the warehouse layout, storage of goods, and picking paths under each scenario, and can realistically simulate the execution of each scenario through virtual reality. This allows students to understand and compare the advantages and shortcomings of each scenario more deeply, so as to find out the most effective warehouse planning program. In addition, the virtual operations session focused on developing students' analytical and problem-solving skills. Students need to utilize the data and charts provided by the MR system to conduct qualitative and quantitative analyses of various warehouse planning scenarios. This not only requires them to understand and apply knowledge of the principles of distribution center operations, but also to acquire skills in data analysis.

(2) Utilize VR technology to create desktop simulation scenario elements. The use of VR technology to build a simulation of automated warehouses, e-commerce warehouses, site layout, business steps, can be from the theoretical cognition, practical testing, process design, site planning, role-playing point of view of a full range of experiential learning, while maximizing the display and experience of wisdom, intelligent equipment in the use of modern enterprises, to achieve the logistics personnel professional knowledge, operational skills, and decision-making ability to achieve the comprehensive training. VR technology is used to truly restore the different functions of logistics equipment, integrating cognition, experience and interaction to strengthen students' overall cognition of logistics equipment. Through VR technology and interactive operation, students can deepen their mastery of logistics knowledge, such as: container size, classification and the knowledge and understanding of famous shipping companies.

4 Empirical analysis

4.1 Logistics machinery intelligent operation and maintenance simulation system testing and analysis

Intelligent operation and maintenance simulation system of logistics machinery is accomplished through the cooperation of Unity3D and other software, and users need to operate the simulation through the computer terminal.

4.1.1 Processes

(1) The user opens the virtual simulation system through the computer and subsequently arrives at the system interface before the operation.

(2) Through the desired operation, the user utilizes the keys in the operation interface to complete the technical action of the target equipment, for example, the stacker cranes carry out the in and out action of the goods.

(3) After completing the experimental operation of logistics and transportation, the user clicks on the stop button to end the work of the equipment, and clicks on the exit button to exit the simulation system, completing the use of the virtual simulation system.

4.1.2 Analysis of simulation results

The actions of the virtual simulation experiment system and the equipment actions of the intelligent logistics experiment center are timed, and the simulation results are shown in Figure 5. Comparison of the time consumption of the four actions of the overhead crane gripping (Action 1), the box into the warehouse (Action 2), the box out of the warehouse (Action 3) and the material conveyance (Action 4), we can get the delay of the virtual simulation experimental system and the actual equipment action of the Intelligent Logistics Center are 1.3s, 0.5s, 1.6s and 1.3s respectively, and the delay time of each action are less than 2s, can meet the teaching task of logistics operating system.

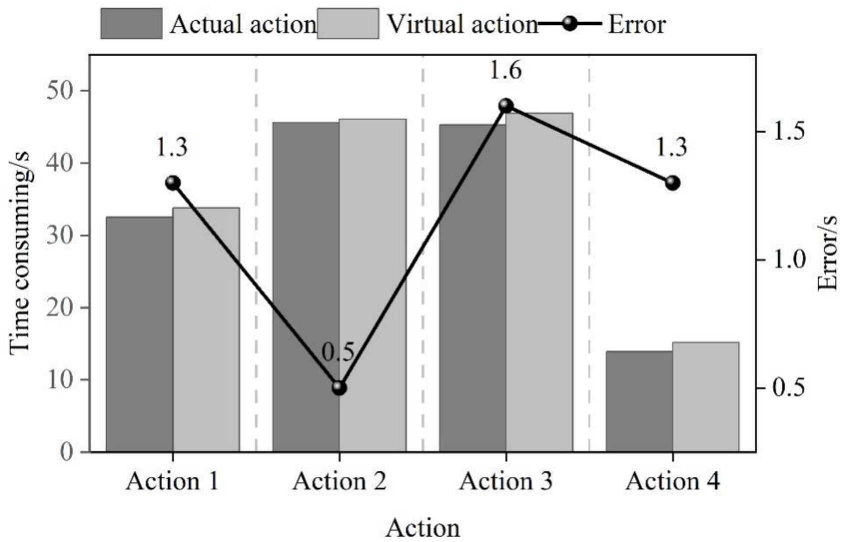

Figure 5: The actual action of the equipment and the simulation action comparison

4.2 Detection and Analysis of Supply Chain Risk Early Warning Simulation System

4.2.1 System data detection rate

In order to simulate the attacker's tampering attack on three different data in the supply chain risk early warning simulation system (demand, inventory movement and unit cost), different parameters, such as input variables and static variables, are randomly selected in the source file of each test program and the values of the parameters are modified. Then the tampered program is run on the test platform and it is observed whether the system is able to detect the attack or not. Meanwhile the number of attacks is set to 50, 150, 250, 350, 450 and 550 times. The detection rate of the system for the three different data tampering attacks in the supply chain is shown in Fig. 6. The detection rate of the three different data tampering attacks decreases with the increase in the number of attacks, but the decrease is low, with a maximum decrease of 1.7%, mainly because the supply chain risk warning simulation system has enough space in the memory for large-scale fault monitoring. And the detection rates of three different data tampering attacks are all greater than 98.3%, which further highlights that the supply chain risk warning simulation system constructed in this paper can effectively detect data tampering attacks. In addition, attacks on supply chain demand and inventory changes are more easily detected, with the maximum detection rate of 99.5% and the minimum of 98.4% for inventory changes.

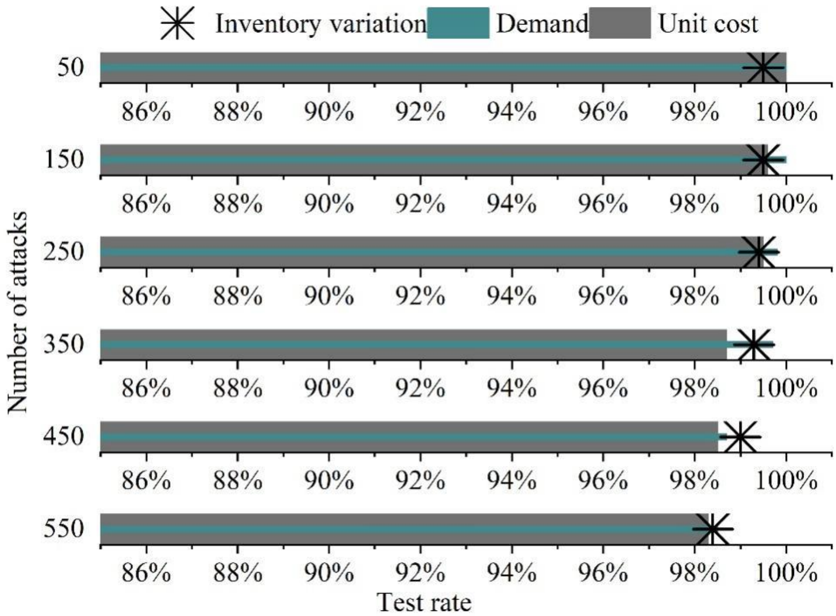

Figure 6: Statistics of data attack detection rate

4.2.2 System Single Node Data Detection

If the attacker's resources are limited, it is necessary to attack a single node in the supply chain risk warning simulation system to realize the data codification attack. Therefore, the method proposed in this paper for detection based on sales price changes is compared with random forest model (RF) and deep learning model (CNN) to evaluate the accuracy of the three methods for detecting single node codified data in the system. The comparison results are shown in Fig. 7. When the number of training times is 100, the detection accuracy of the method based on sales price changes is greater than that of the random forest model and the deep learning model. The detection accuracy of the detection method in this paper finally reaches 90.1%, compared with 86.4% and 89.3% for the random forest model and deep learning model, respectively. Therefore, the detection accuracy of single node codification data of the detection method based on sales price change is better than random forest model and deep learning model.

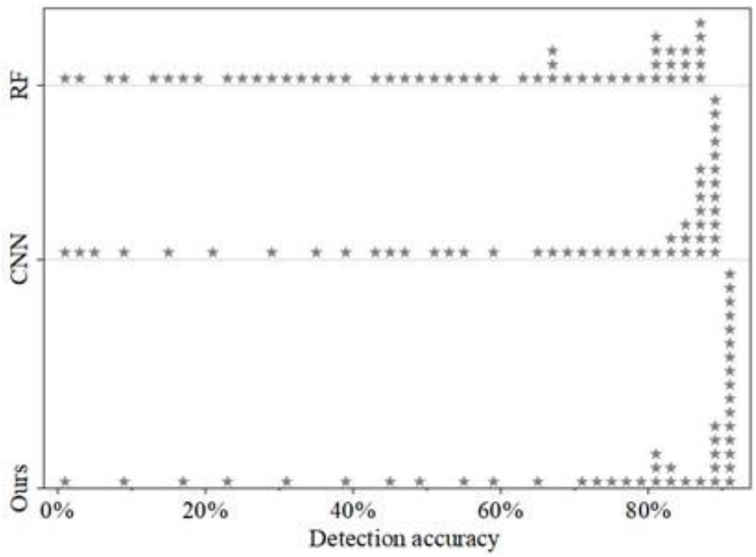

Figure 7: System single node data detection comparison

4.2.3 Impact of different tampered data attack power on detection results

Attackers use different attack powers when they carry out tampering data attacks on the supply chain risk warning simulation system, the lower the attack power, the smaller the detected changes in the basic blocks, and the attack is not easy to be detected. Therefore the detection accuracy corresponding to different attack power is studied and the detection results are shown in Fig. 8. As the attack strength increases, the detection accuracy increases. Setting the attack power to 1W, the detection accuracy is only 47.64%, which is less efficient. Due to the low power, the protective wall of the supply chain risk warning simulation system can directly intercept the tampering data attack, which has less impact on the system. When the attack power reaches 6W, the detection method based on the sales price change situation has excellent detection effect, and the detection accuracy is 95.29%. As the attack power increases, the detection accuracy rate still shows an increasing trend, but the increasing trend is smaller. When the attack power is 10W, the maximum detection accuracy of the proposed detection method based on sales price changes is 97.43%.

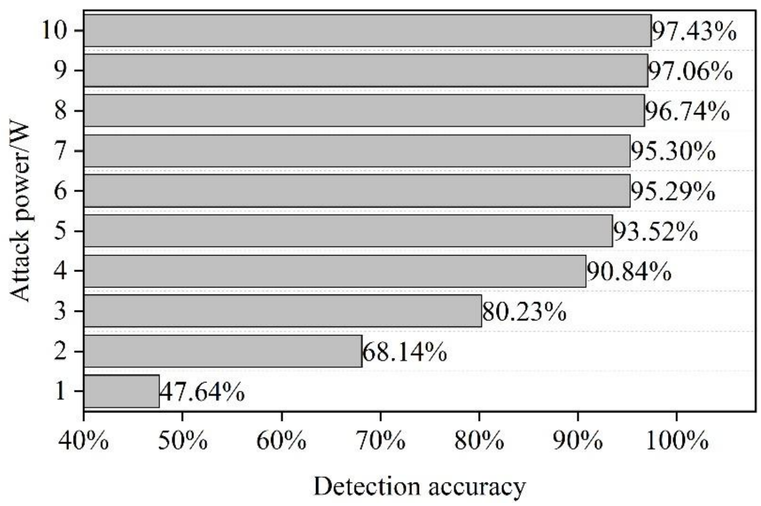

Figure 8: The effect of different data attack power on test results

4.3 Effectiveness of virtual simulation teaching and learning

In order to compare the effect of teaching reform, two classes of students majoring in supply chain management in A higher vocational college are taken as the research object, class A (40 students) is taught by traditional lectures and enterprise internships, and class B (40 students) is taught by practical teaching based on the practical training teaching scenario of industry-teaching fusion and virtual simulation designed in the previous article, and a satisfaction survey and teaching evaluation are carried out for a total of 80 students of the two classes at the end of the period. Comparative analysis of the results.

Data were collected through the background of Questionnaire Star, 80 questionnaires were received, 80 valid questionnaires, with a validity rate of 100%. Each item in the satisfaction survey has five options: "Very satisfied", "relatively satisfied", "basically satisfied", "not very satisfied", and "very dissatisfied", and is scored from 5 to 1 point in sequence. The teaching evaluation was designed with questions in five dimensions: frequency of interaction, frequency of questions, effectiveness of practical training, quality of teaching and course understanding.

In this study, the Cronbach's coefficient, which is currently commonly used, was used to check the internal consistency of the questionnaire, and the reliability test is shown in Table 1. The overall Cronbach's Alpha coefficient of the scale = 0.955, and the Cronbach's Alpha coefficients of the main factor scales are all greater than 0.9, with high internal consistency and good overall reliability of the questionnaire.

Table 1: Reliability analysis

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.955	0.832	20

Validity was verified using KMO and Bartlett's test, and the validity test is shown in Table 2.KMO=0.933, which is greater than 0.8, indicating that the validity of the research data is high, and $p<0.0001$, which indicates that the questionnaire validity is good.

Table 2: Validity analysis

Kaiser -Meyer-Olkin Measure of Sampling Adequacy		0.933
Bartlett's Test of Sphericity	Approx.Chi-Squeare	11063.625
	Df	365
	Sig	0.000

The results of the student satisfaction survey are shown in Figure 9. By analyzing the survey of the two classes, it can be found that the students' acceptance of the new method is as high as 87.5%, and the acceptance of the traditional method is only 50%.

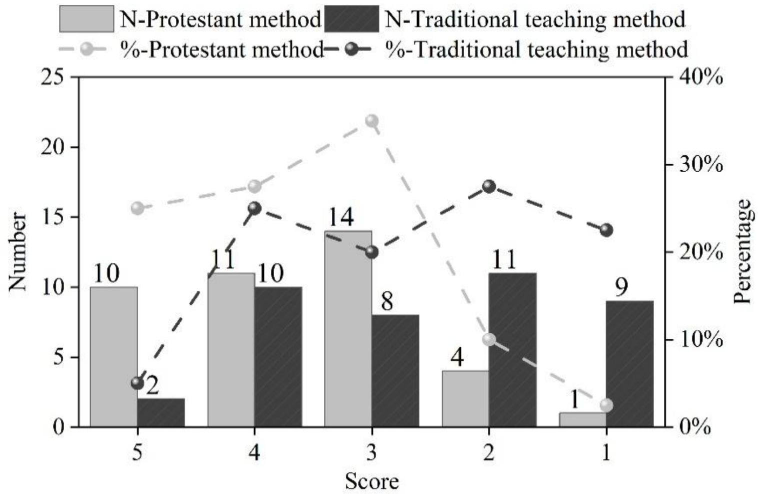

Figure 9: Student satisfaction survey results

The comparative analysis of student teaching evaluation results is shown in Figure 10. The teaching effect is obviously improved a lot after adopting the virtual simulation platform, such as the frequency of student interaction, the number of questions increased significantly, and the understanding of the course increased to 76.9% compared with 32.1% in traditional teaching. The effect of practical training is better, and the basic operation skills of students are significantly improved.

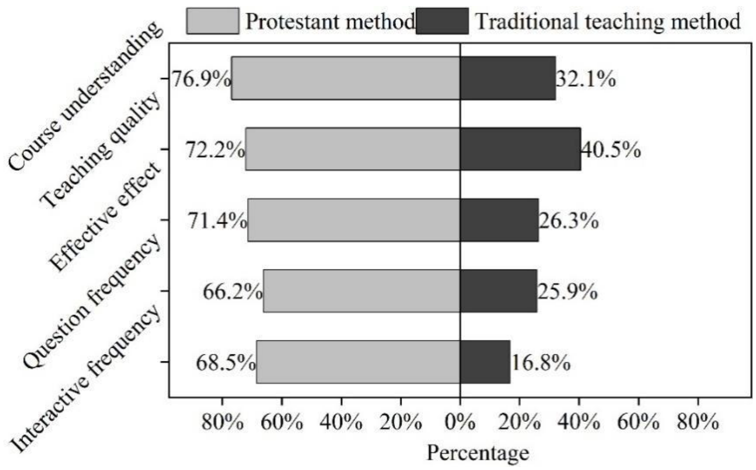

Figure 10: Comparison analysis of student teaching evaluation

5 Conclusion

The study is based on the virtual simulation training system constructed to develop practical training teaching scenarios that can meet the demand for skill development through the deep cooperation between schools and enterprises in the integration of industry and education, so as to promote the reform of practical teaching. When the logistics machinery intelligent operation and maintenance simulation system involved in the virtual simulation training system carries out the actions of overhead crane gripping, box in storage, box out of storage and material conveying, the time consumed is delayed by 1.3s, 0.5s, 1.6s, and 1.3s respectively compared with the actions of the actual equipment, and the delay time is within the acceptable range. The method of detecting based on the change of sales price adopted by the involved supply chain risk early warning simulation system has a high detection accuracy rate, which can reach 90.1%. When using the method of this paper for practical training teaching, the frequency of student interaction, the number of questions significantly increased, and the acceptance of the method is as high as 87.5%. The method of this paper has strong application potential in the reconstruction of the practical course system and the development of practical courses, and helps to promote the reform of practical teaching.

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