Exploration on virtual simulation teaching practice for safe operation of high-voltage system of new energy vehicles

Xihong Xue[a], Feng Wang[b], Mingjiang Wu[c*], Alishati Abriz[d]

Xinjiang Vocational University, Urumqi, Xinjiang, China

[a]739527793@qq.com, [b]524563112@qq.com
[c*]2457794121@qq.com, [d]1943420258 @qq.com

Abstract. New energy vehicles usually use high-voltage battery systems. The voltage of these battery systems typically ranges from 300V to 800V, which is much higher than the 12V batteries of traditional gasoline vehicles. The article elaborates on the current limitations of new energy vehicle technology professional teaching, analyzes problems in teaching equipment and practical training, and uses modern information technology to teach professional courses, which is conducive to improving the teaching effect of vocational education. The article relies on Luckeside virtual simulation teaching equipment, takes the safe operation of high-voltage systems as an example, uses virtual simulation teaching methods to carry out teaching practice that integrates ideological and political courses, leads the curriculum revolution, and creates typical cases for new energy vehicle technology practical operation courses.

Keywords: new energy vehicles; safe operation of high-voltage systems; virtual simulation teaching methods; information-based education.

1 Introduction

The new energy vehicle high-voltage safety protection course mainly learns the use of new energy vehicle high-voltage operation detection equipment and tools; basic electrical knowledge, including high voltage levels and safe voltages, hazards caused by current, and identification of high-voltage areas in new energy vehicles; high-voltage safety and Protection, master the protective measures to avoid high-voltage injuries, maintenance workshop safety protection and first-aid measures; master the requirements of high-voltage safety regulations; high-voltage suspension (cutting off the circuit) standard process operations, etc., laying the foundation for subsequent new energy vehicle professional courses. The safe operation of high-voltage systems involves voltages that endanger human safety. There are safety risks in operating directly on the actual vehicle. With the help of modern virtual simulation teaching tools, simulations of real-world scenarios can be provided to help students conduct practical operations

M. Yu et al. (eds.), *Proceedings of the 2024 5th International Conference on Big Data and Informatization Education (ICBDIE 2024)*, Advances in Intelligent Systems Research 182,
https://doi.org/10.2991/978-94-6463-417-4_28

and experience in a safe environment. thereby improving their skills and knowledge levels [1-2].

2 New energy vehicle high voltage system

2.1 Power battery pack

Pure electric vehicle power battery packs are composed of many battery modules, single cells, battery management systems, power battery boxes and auxiliary components. Single cells and battery modules are connected in series and parallel to increase the voltage of the power battery pack to more than 300V. High voltage helps to improve the energy density and overall performance of new energy vehicles, thereby increasing the vehicle's cruising range and improving power output. [3].

2.2 High voltage control box

The high-voltage control box is the hub that connects the power battery and various electrical equipment to realize the output and distribution of power. It also contains PTC, compressor, DC/DC, and vehicle charger fuses to play a protective role [4].

2.3 Motor drive system

The motor drive system includes a drive motor and a motor controller. The function of the drive motor is to convert electrical energy into mechanical energy. The function of the motor controller is to convert the DC power from the power battery into AC power for use by the motor, while accurately controlling the motor to work according to the driver's intention.

2.4 DC/DC converter

There are two power sources in pure electric vehicles, one is the power battery and the other is the low-voltage battery. The power source of the low-voltage battery of traditional fuel vehicles is that the engine drives the generator to generate electricity to charge it when the engine is working. The power source of the battery of pure electric vehicles is the power battery, The function of the DC/DC converter is to convert the high-voltage DC power of the power battery into low-voltage DC power to charge the 12V battery.

2.5 Car charger

The electric energy storage device of new energy vehicles is a power battery, which stores electric energy in the form of direct current. The function of the on-board charger is to convert the alternating current into direct current and then transport it to the power battery.

3 Current status of new energy vehicle teaching

The learning and practical training of batteries, motors, and electronic controls for new energy vehicles are the core content of the new energy vehicle technology major. However, during the teaching process, the safety hazards of high-voltage systems are relatively abstract. Students have insufficient knowledge of "electricity" related knowledge, resulting in weak safety awareness, or are too afraid and nervous during practical training operations, and cannot fully grasp the teaching and training content.

3.1 Problems with practical training equipment

New energy vehicles are developing rapidly, and product technology is constantly updated and iterated. The teaching of new energy vehicles in vocational colleges focuses on practical operations, so the requirements for practical training equipment are relatively high. Currently, the practical training equipment in vocational colleges has the following problems:

First, the existing types of training equipment do not meet the needs of the new energy automobile industry for comprehensive talents. Different from traditional internal combustion engine vehicles, the structural structure, power source, and maintenance methods of new energy vehicles have undergone great changes. This Relevant practitioners are required to not only have the professionalism of traditional automobile majors, but also have the "new" knowledge and skills of new energy vehicles, such as high-voltage safety operations, battery structure, motor drive principles and maintenance, etc. Current training equipment Most of them are internal combustion engine teaching equipment, which cannot meet the needs of new energy vehicle professional teaching.

Second, the scale of practical training equipment is insufficient. The number of existing practical training equipment sets in the automotive training base is not enough to provide practical training for the increasing number of automotive major students year by year and needs to be improved.

Third, the existing equipment does not meet the intelligent trend of future development of new energy vehicles. Market demand is the starting point and foothold of talent training. The existing training equipment does not have the direction of intelligent network connection, so it is necessary to build equipment related to intelligent network vehicle. , closely integrate with the market and adapt to dynamic changes in the market.

Fourth, the maintenance of practical training equipment is difficult. Some practical training equipment may have high technical complexity, and maintenance and repair require professional knowledge and skills, which may cause difficulties. Parts for some training equipment may be difficult to obtain, especially for some old equipment or imported equipment, which may lead to maintenance difficulties. Maintaining, repairing, and updating training equipment requires investment, and if budgets are limited, maintenance difficulties may become a problem. Sometimes the skills and knowledge level of maintenance personnel may not meet the needs of training equipment maintenance, which may also cause difficulties. Equipment aging: Some equipment may become difficult to maintain due to aging, which may require more frequent and complex maintenance work.

Fifth, the equipment of the existing training center is old and not closely connected with the market. Social resources need to be utilized. Cooperation between schools and enterprises must be strengthened, and the communication channels between schools and enterprises must be opened up and broadened. Our school's automotive training base is used as a The hub attaches great importance to creating a real environment close to the enterprise, simulating the production site and the management methods of modern enterprises, and planning various practical training projects according to industry needs, so that students can be immersed in the situation and have a basic understanding of professional technology, and not only acquire theoretical knowledge, but also Have a comprehensive grasp of automotive professional knowledge and possess industry practical capabilities.

3.2 Issues in practical teaching

First, The construction of teachers in the practical training center needs to be strengthened. Teachers play a leading role in the training of applied talents. The updating of teaching concepts, the formulation and implementation of teaching reform plans, the teaching quality assurance system and the management and operation system of the practical teaching base all rely on teachers. At present, the teaching team of the training center lacks deep professional knowledge and rich practical training experience in new energy vehicles and intelligent connected vehicles. They need to continuously improve their own level and consolidate their theoretical and practical skills foundation.

Second, Practical teaching involves high pressure and there are safety risks in the training process. For battery systems and high-voltage electrical components of new energy vehicles, maintenance personnel need to pay special attention to safe operations and need to receive special training to ensure that they follow correct operating procedures and use special safety protective equipment. In order to ensure the safety of students, some colleges only practice simpler projects or maintenance work after power outage during practical operations, which is not conducive to the improvement of students' knowledge and skills.

Third, Professional (group) social service capabilities are insufficient. Social service capabilities need to be strengthened and efforts should be made to share and fully utilize construction resources. On the basis of overall planning, make full use of on-campus and off-campus resources to avoid duplication in the construction of on-campus training bases. Try to focus on building according to industrial groups and technology application categories, do not emphasize one-to-one correspondence with established majors, achieve resource sharing, effectively implement the talent training model of "school-enterprise cooperation, work-study integration", and achieve a high degree of integration between schools and enterprises, so that The cultivation of talents meets the standards of enterprise needs, the development of service industries and the construction of local economy.

3.3 New teaching model for new energy vehicle major

At present, the teaching models of new energy vehicle technology majors in my country's vocational colleges are becoming more and more novel and diversified. For example, Deng Chunzhi and others proposed four applications of AR technology in new energy vehicle professional teaching. One is the application in driving training, which relies on driving simulation. The device allows students to intuitively experience a variety of real driving scenarios, with different weather, lighting, pedestrians and other factors, bringing an immersive interactive experience. The second is the application of automobile testing, which can realize various performance tests such as collision resistance and anti-skid performance on different simulated roads. The third is the application of comprehensive automobile fault diagnosis. Through wearable devices, students can observe the working process of new energy vehicles in detail, thereby mastering the knowledge of new energy vehicles more vividly. The fourth is the application of automobile maintenance. The software simulates the maintenance process of the four major modules of the new energy vehicle body, electrical appliances, chassis, and motor, allowing students to learn the maintenance training operations of new energy vehicles in a safe environment [5].

Ren Lu explored the course implementation process using the "virtual live broadcast + remote training" teaching model. The teaching environment is built with virtual teaching software and an online teaching platform, which can realize the release of teaching materials and learning tasks before class, and virtualization during class Live teaching, after-class practice evaluation and reflection teaching throughout the process [6].

Liu Huarui explored the application of virtual simulation technology in the teaching reform of new energy vehicle majors and suggested three specific applications. One is to build a multi-disciplinary virtual training environment covering multiple disciplines such as electrical engineering, electronics, and machinery [7].

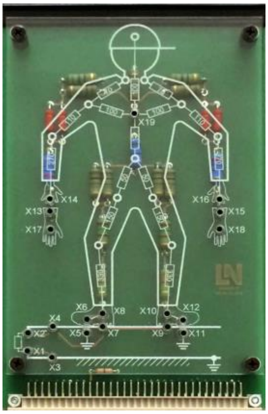
Li Bo and others conducted research on the new energy vehicle teaching interactive system, taking the new energy vehicle Qin EV and the supporting teaching interactive system as an example to introduce its application in curriculum design, teaching method reform, practical teaching, evaluation feedback, etc. [8]

4 High Voltage System Safety Operation Simulation Training Course

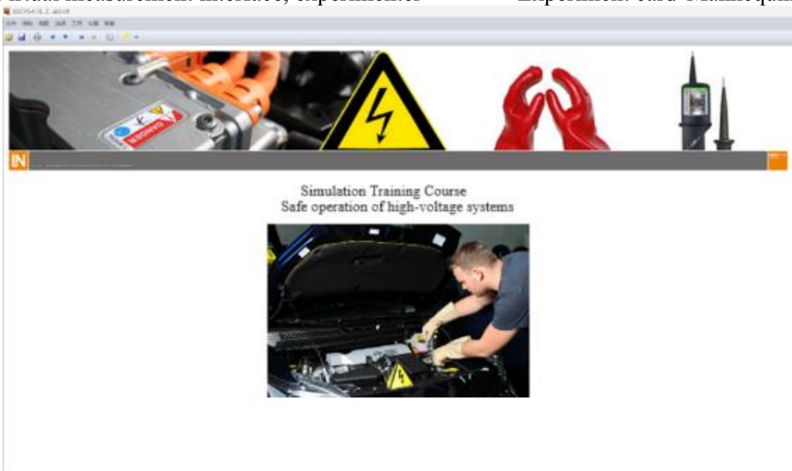
4.1 Practical training equipment

Luckeside's virtual simulation training course includes practical training equipment (virtual measurement interface, experimental equipment, experimental cards, measurement wires, resistors representing the resistance between various parts of the human body) and course software, as shown in Figure 1. The operational safety of high-voltage systems is the top priority in preventing accidents in new energy vehicle operations. The goal of this course is to detect and learn how to prevent life-threatening and personal injuries caused by electric shock to the body. Even small currents must not be taken lightly. Operators must be able to distinguish between DC and AC electric shock currents.

Virtual measurement interface, experimenter



Experiment card"Mannequin"



Course software

Fig. 1. Luckeside virtual simulation training equipment

4.2 Teaching implementation process

1) Introduction before class

An electric car has been severely damaged in an accident and is towed to your repair shop. A colleague who received the car must now take it to a dedicated secure area. details as following:

The crew towing the badly damaged car hurried toward the parking space when they heard a scraping sound. Without turning off the vehicle's ignition, they left the car to investigate the cause of the scratching. They discovered that the high-voltage air conditioning compressor had been damaged and had been dragged along. To lift and reinstall the high-voltage air conditioning compressor, they opened the hood and placed one hand on the inverter in the engine bay while trying to lift the compressor with the other hand. Suddenly, they suffered an electric shock and immediately passed out.

Discuss the above scenario in groups and answer the following questions:

Can you work on a high-voltage vehicle that has been involved in an accident and whose safety status is unknown, without taking any additional precautions?

Yes, high voltage cars are always inherently safe.

No, it must be clear whether there are any risks to the high-voltage vehicle involved in the accident.

The voltage of high-voltage cars can be within a safe range.

Cultivate students' safety awareness through actual electric shock cases.

2) Inquiry in class

Exercise 1 Determine the average resistance of the human body along the "hand-to-hand" path on the lab card.

Read the resistance of each human body on the experiment card and add it up. What do you get by adding the resistances between your hands? 480Ω, 960Ω, 1400Ω.

Set up the experiment and measure the resistance according to the animation, as shown in Figure 2. What is the resistance between the hands measured on the experiment card? The conclusion is 960Ω.

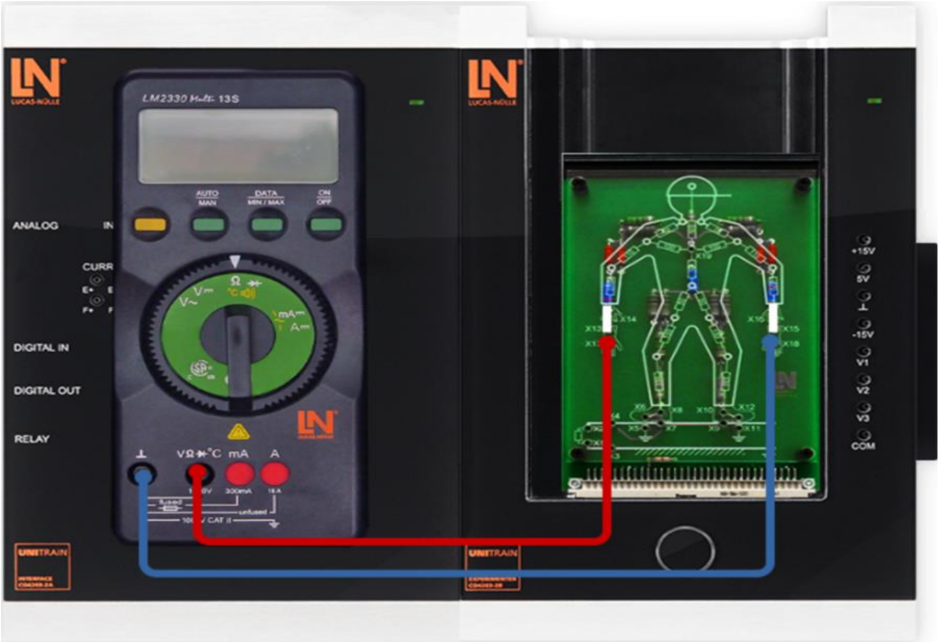


Fig. 2. Measure the average resistance of the human body along the "hand-to-hand" path

Exercise 2 Use a multimeter to determine the resistance of your own body.

The first step is to dry your hands. Hold one measuring end with the thumb and index finger of your left hand, and the other measuring end with the thumb and index finger of your right hand, as shown in Figure 3. Read the resistance value:

Fig. 3. Measure the resistance of your own body

Step 2 Wet your fingertips and take another measurement

Compare the resistance when your hands are dry to the resistance when your hands are wet. How do wet fingers change the body's electrical resistance? The resistance remains the same, the resistance increases, the resistance decreases, and the measurement result is a decrease in resistance.

Through the above exercises, we can find out that the size of the human body's resistance is affected by the following factors: body shape (fat, thin, tall, short, joint thickness); uniformity of the skin (thick, thin, dry, wet); the size of the resistance is also Varies from person to person.

Exercise 3 Danger caused by DC electric shock

According to the animation setting experiment, as shown in Figure 4, a voltmeter A was used in the simulation software to measure the battery voltage of 30V when the ignition switch was turned on. The experiment found that the measured voltage was 10 times smaller than the vehicle voltage. The battery power-off system was turned off through switch S1. Turn on the ignition switch, wait more than 20 seconds, and measure the voltage again to 0V.

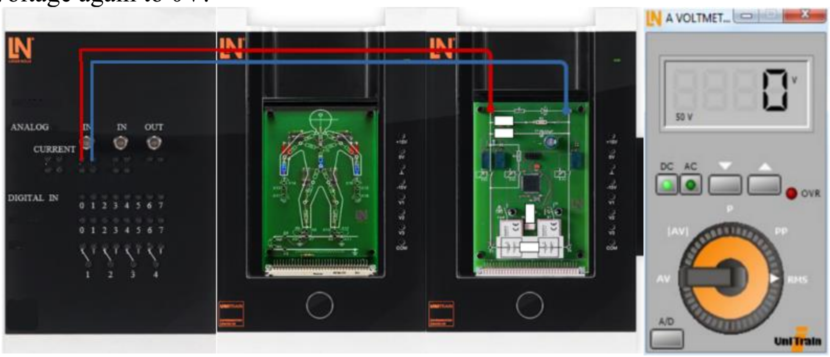


Fig. 4. Measuring power battery voltage

Through experiments, it was concluded that if the maintenance workshop personnel had turned off the ignition switch before checking the cause of the vehicle damage, then this tragedy might not have happened. Compare the correct and incorrect operation results, and once again emphasize the awareness of compliance with professional regulations and safety awareness.

Exercise 4: Measuring the current through the human body.

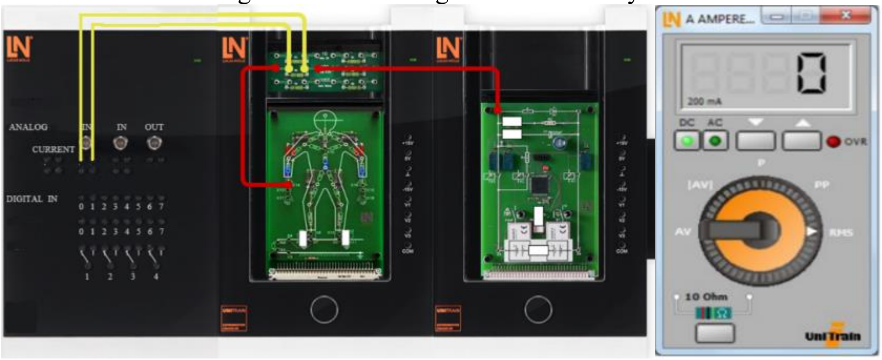


Fig. 5. Measure the current flowing through the human body

Set up the experiment according to the animation, as shown in Figure 5. Use ammeter A in the simulation software to measure the current passing through the human body. Use S1 on the experiment card to turn on the ignition switch and wait for relays K1 and K3 to appear. The measured current at 30V is 30mA. The current measured at 300V is 10 times the current at 30V.

The group discusses whether electric current at about 300V poses a danger.

Exercise 5: Measuring the resistance of personnel working on high voltage systems wearing safety gloves

According to the animation installation experiment of setting up jumper wires to simulate electrical protective gloves, measure the resistance and answer the question: What is the resistance of the human body when wearing electrical protective gloves? Greater than 10 MΩ/infinity; equal to 1 kΩ; 0 Ω. The result is: greater than 10 MΩ/infinity. The experiment found that electrical protective gloves can effectively protect personnel from electric shock, and reminded students that only gloves in good condition can fully exert their protective effect. For this reason, your protective gloves should be inspected before each use.

Actual work scenarios are created in the course, and the "teaching, learning, doing, and thinking" integrated teaching model is adopted to guide students to fully participate in the topic through experimental inquiry, group cooperation, brainstorming and other learning activities, and actively think and understand the course content, achieving Learn by doing, learn by doing. It is emphasized that specific safety regulations must be observed when working on high-voltage systems: all connections to the system must be disconnected, the system must be protected against accidental start-up, and the system must be able to prove a complete loss of power. During the process of experimental exercises, students can experience the awareness of complying with professional norms, safety awareness, group cooperation and communication, self-analysis and problem solving, rigorous and meticulous ideological and political goals, and achieve the effect of ideological and political education that moisturizes things silently.

3) After-school *development*

Set up test exercises on course-related knowledge, professional standards, safety and rigor, etc., and complete group self-evaluation, peer evaluation, and teacher evaluation forms. After class, students can be asked to explore and study on their own, complete laws and regulations, operating precautions, environmental protection regulations, etc. related to the safe operation of high-voltage systems, and display the results in the form of presentations, themed articles, recorded videos, etc.

5 Conclusions

This article analyzes the problems existing in the teaching of new energy vehicle technology, and explores the application of VR, "virtual live broadcast + remote training", virtual simulation technology, and teaching interactive system in the teaching of new energy vehicle technology, focusing on *Basics of Electricity and High Voltage Safety* Taking the safe operation knowledge of high-voltage systems in the course as an example, the implementation of teaching that incorporates ideological and political education is completed, including: pre-class introduction, in-class exploration, and after-class extended teaching. In the future, it is necessary to further expand the application scope of modern new education models in new energy vehicle professional teaching and improve the quality and fairness of education.

References

1. Jiulong Wang, Bingquan Wang, Lei Zhang, Jianjun Wang, W,(2022)Review of bidirectional DC–DC converter topologies for hybrid energy storage system of new energy vehicles. New Energy and Intelligent Transportation (English) ,1(2):33-50.
2. Ali Gholami Trojani, Mahmoud Samiei Moghaddam, Javad Mohamadi Baigi. T, (2023)Stochastic Security-constrained Unit Commitment Considering Electric Vehicles, Energy Storage Systems, and Flexible Loads with Renewable Energy Resources. Journal of Modern Power Systems and Clean Energy ,11(5):1405-1414 .
3. Modeste Venin Mendieev Nitou, Yashuai Pang, Zhao Wan, Wenjun Li, Zhuohang Zhong, Waqas Muhammad, Saeed Muhammad, Sohail Muhammad, Yinghua Niu, Weiqiang Lv, J. (2023) LiFePO_(4)as a dual-functional coating for separators in lithium-ion batteries: A new strategy for improving capacity and safety. Energy Chemistry: English Version,11:490-498I0010.
4. Imran Khan, Firdaus Muhammad-Sukki, Jorge Alfredo Ardila Rey, Abdullahi Abubakar Mas'ud, Saud Jazaa Alshammari, DagØivind Madsen. (2023)A Joint Optimization Algorithm for Renewable Energy System. Intelligent Automation and Soft Computing(English), 5:1979-1989 .
5. Deng Chunzhi, D. Li Shuliang. L. (2023)Application of AR technology in new energy vehicle professional teaching . Automobile Test Report, 09:124-126.
6. Ren Lu, L. (2023)Exploration and practice of the "virtual live broadcast + remote training" teaching model of the "New Energy Vehicle Maintenance and Fault Diagnosis" course. Southern Agricultural Machinery, 54(16): 171-174.
7. Liu Huarui, L. (2023)Application of virtual simulation technology in the teaching reform of new energy vehicle majors . Automobile Test Report, 15:137-139.
8. Li Bo, L. Du Xiubo, D. Dong Zhimin, D.et al. (2023) Exploration and practice in teaching based on new energy vehicle teaching interactive system. Times Automobile, 23:28-30.