Study on the Campus Power Distribution System Assisted Teaching of Power Supply Technology

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***Abstract*—Campus facilities serve for talent cultivation and are the stakeholders of teaching activities, which can play a unique auxiliary role in the teaching of related courses, especially during the COVID-19 epidemic. Taking the teaching of power supply technology as an example, this paper illustrates the position, role, and utilization mode of campus power distribution system in the teaching of power supply technology. By visiting the campus central substation, taking the campus power distribution system as a case study, and using the campus substation as a real-type experiment laboratory, theoretical teaching has been effectively supplemented, and the effect of engineering education has been greatly improved.**

***Keywords*—campus power distribution system, campus facilities assisted teaching, real-type experiment, power supply technology**

I. Introduction

Practice in enterprises is an important way to cultivate talents and an important supplement to classroom teaching in higher engineering education. Practice will play an irreplaceable role in improving students' engineering awareness and practical ability, and promoting their understanding of industrial production activities [1]. However, since the emergence of COVID-19, it has greatly increased the uncertainty of enterprises' practice, and has seriously affected the cultivation of practical ability of engineering education [2]. Although online practice has emerged as the times require and to some extent makes up for the loss of talent training caused by the lack of practice [3–5], the personal experience of being on the scene and the perceptual knowledge of facing the real object are still lacking. In fact, many campus facilities can be used as practice tools and play a special role in assisting curriculum teaching.

Take the course teaching of Electric Power Supply Technology as an example. Electric Power Supply Technology is a required professional course for electrical engineering and automation majors, mainly teaching the composition and structure of user power distribution system, main wiring design, equipment selection, protection monitoring, operation and maintenance, and how to improve power efficiency and ensure power supply quality [6]. Power supply technology is the terminal technology in the four links of power generation, transmission, distribution, and consumption in the power system, and is an important guarantee for all production and living activities in today's society. Through long-term practice, exploration and improvement, Xi'an University of Technology has gradually formed a multi-channel comprehensive teaching mode of cognition practice, theory teaching, curriculum experiment, curriculum design in the teaching of Power Supply Technology, which has achieved good teaching results. However, in recent years, the repeated occurrence of COVID-19 has disrupted the original teaching order, especially the practice in enterprise' substations that cooperate with the course teaching cannot be carried out normally, and students lack practical understanding in the course learning process.

In fact, the campus is also a typical terminal power user. In the form and design method of power distribution system, it is the same as industrial enterprises, commercial and residential buildings, and other power users, and it is convenient, safe and at stake in teaching. Some colleges and universities have established power supply practice bases on campus, or used the campus power distribution system to carry out case teaching and cognitive practice [7, 8], which has achieved good results, but did not further clarify the organic coordination between the campus power distribution system and the course teaching process. Therefore, how to use the campus power distribution system to assist the teaching of Power Supply Technology is worthy of in-depth discussion.

In this paper, the unique role and advantages of the campus power distribution system assisted teaching of Power Supply Technology is expounded in Section II. Then, combined with the teaching content and process of Power Supply Technology, the methods and approaches of campus power distribution system assisted teaching is discussed in detail in Section III. And finally, the results of the campus power distribution system assisted teaching of Power Supply Technology is explained in Section IV.

II. The Role of Campus Facilities in Talent Training

Campus facilities assisted teaching activities have their unique advantages. First of all, all campus facilities and activities are the stakeholders of teaching activities, and

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centering on the central task of talent training in higher engineering colleges. Therefore, campus facilities should be used to assist classroom teaching. Secondly, the practice schedule based on campus facilities is basically free from the interference of external factors, and can keep pace with classroom theoretical teaching in the teaching process. Moreover, practicing on campus is safe and economical, and students are familiar with campus activities, which is easy to arouse students' interest. Campus power distribution system assisted teaching of Electric Power Supply Technology is a typical example.

Compared with industrial electric power users, the campus power distribution system has both commonalities and its own characteristics in terms of composition, structure, design method, operation requirements, etc.:

(1) The campus belongs to a densely populated public place, and its electrical equipment belongs to a typical class II electric loads.
(2) The university campus covers a wide area, has many kinds of electric loads and a large demand for power supply capacity. The campus is generally located in the urban center, with short upstream power supply distance and 10kV power supply voltage.
(3) The campus often adopts dual power supply, with a two-level structure of central substation (general substation or general distribution substation) and 10kV substations (workshop substations) in the subordinate area. The substations often are indoor or box type, and the outdoor power grid mostly adopts cable radial connection.
(4) In the campus, there are many single-phase loads, such as computers, office electronic equipment, experimental instruments and equipment, this leads to a serious three-phase current imbalance and harmonic problems. But the precision scientific research equipment in turn has high requirements for power quality, so dynamic reactive power compensation and harmonic mitigation equipment are often standard configuration [9].

Campus substation, as a key part of talent training in engineering colleges and universities, should be responsible for cooperating with the teaching of Power Supply Technology for electrical engineering students and accepting students to visit and practice. On the premise of ensuring the safety of power supply, the campus power distribution system can meet the needs of the teaching of Power Supply Technology, and become a campus practice base for students' cognitive practice. If conditions permit, individual substations can also be taken out to further develop as a power supply technology training base for students.

III. Methods and Approaches of Campus Facility Assisted Teaching

The role of campus facilities in teaching activities can be varied. Typical roles include visiting practice bases, case teaching objects, real-type experimental places, etc. As far as power supply technology teaching is concerned, campus power distribution system is both the object and the result of the course teaching. The campus power distribution system can play a comprehensive role in promoting the whole process of power supply technology teaching.

A. Visit Campus Power Distribution System to Strengthen Students' Understanding of the Power Supply Technology

Substation is the core of user power distribution system, and also the focus of power supply technology teaching. In the teaching process of power supply technology course, in combination with the teaching content, we will lead students to visit the campus substation and its distribution network in person, in order to strengthen students' overall perceptual understanding of the substation and distribution network, and promote a deep understanding of the classroom teaching content. The main purposes of visiting the campus central substation and its subordinate 10 kV substations are:

(1) To understand the overall architecture of the campus power distribution system, including the campus power supply, power supply voltage level, power supply capacity, and the setting and layout of the campus central substation and its subordinate 10 kV substations.
(2) Be familiar with the composition and structure of the central substation, the structure and type of high-voltage bus and high-voltage switchgear, the structure and function of main high-voltage electrical equipment, and the operation platform for metering, protection, and monitoring of the center substation.
(3) Be familiar with the composition and structure of the 10 kV substation in the subordinate area, understand the structure and brand parameters of the 10 kV distribution transformer; Be familiar with the low-voltage reactive power compensation equipment and harmonic control equipment and understand their functions.
(4) Be familiar with the structure of the low-voltage power distribution system powered for their teaching building.

In order to achieve a good effect of the practice and avoid a cursory glance, the whole process requires careful guidance, explanation, and cooperation from the teachers and on-site engineers. The visit to the campus power distribution system shall be carried out orderly according to the established route and content under the guidance of the site engineer. The teacher shall cooperate with the site engineer, guide the students' attention and observation points, and provide supplementary explanations, analysis, and troubleshooting in combination with the course content and the site situation. The visit to the campus power distribution system can be completed at one time or implemented by several times in combination with the teaching process. Fig. 1 shows a photograph of campus central substation visit under the guidance of the site engineer.

Figure 1. Visiting of campus central substation.

B. *Carry out Case Teaching in Combination with the Campus Power Distribution System*

On the basis of explaining the design method and basic principle of user power distribution system, take the campus power distribution system as an example to implement case teaching. The contents of the case teaching include:

(1) Drawing the main electrical wiring diagram of the campus central substation according to the impression and record of the visit to the campus central substation, and analyzing the design scheme of the campus substation from the four basic requirements of safety, reliability, flexibility and economy.

(2) Based on students' familiarity and understanding of the distribution of power load on campus, taking the setting and layout of the campus central substation and its subordinate 10 kV substation as a case study, let students deeply understand the structure of the user power distribution system and the setting principles of the substation.

(3) Understand the protection configuration and protection settings of 10 kV feeders and distribution transformers in the campus central substation, and calculate short circuit current and check the relay protection settings for the campus power distribution system.

Case teaching is best combined with visiting practice. You can teach cases first and then visit the campus power distribution system, or you can visit first and then teach cases. Each has its own advantages. As the campus power distribution system has the characteristics of being able to visit at any time, if you can visit - case teaching - visit again, the teaching effect will be better.

The introduction of computer simulation in case teaching or project based learning can not only cultivate students' ability to use advanced tools to solve complex engineering problems, but also help improve the vitality and exploration of teaching and stimulate students' initiative and enthusiasm in learning [10, 11]. Students can establish a simulation model of the campus power distribution system, and then a) observe the short circuit current waveform when short circuit fault occurs, b) observe the changes of bus voltage, power supply current, line voltage loss, transformer power loss, etc. before and after reactive power compensation, and c) compare and analyze the differences between the simulation results and the theoretical calculation results. Fig. 2 shows a simulation model of a sample power distribution system with reactive power compensator and fault element based on the software of MATLAB/Simulink.

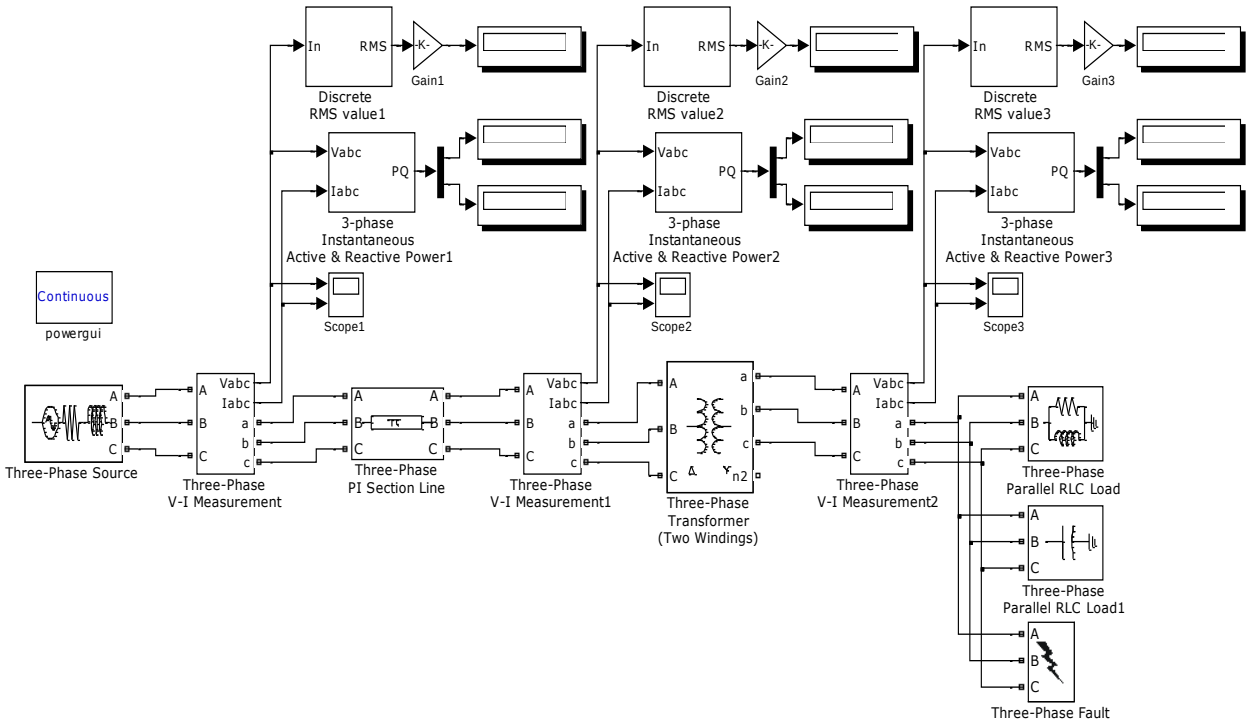

Figure 2. Simulation system of a sample power distribution system.

C. Carry out Real-Type Experimental Teaching of Power Supply Technology Based on the Campus Power Distribution System

Real-type experiment teaching is a comprehensive training mode for practical engineering problems and their solutions. With the help of campus facilities, real-type experimental activities related to teaching content can cultivate students' ability to combine learning with application and use what they have learned to solve complex engineering problems. The campus power distribution system is a good real-type experimental place for power supply technology teaching.

Power quality is the core concern of modern power distribution system, and also the key and difficult point of power supply technology teaching. The real-type experiments related to power quality with the help of the campus power distribution system will be an effective supplementary means to classroom teaching. The real-type experimental teaching can be carried out in the following three levels:

(1) Measure and evaluate the power quality level of the campus power distribution system: through field test of the voltage level, reactive power, harmonic and three-phase imbalance of the campus power distribution system, let students learn how to use advanced instruments such as electric power analyzer and how to measure power quality; through the interpretation and analysis of the test results, let students learn the evaluation methods of power quality and understand the severity of the power quality problems of the campus power grid.

(2) Analyze the effect of the existing reactive power compensation and harmonic suppression devices: Campus substations are generally equipped with group-switching capacitors for reactive power compensation and active power filters for harmonic suppression. By comparing the bus voltage, reactive power and harmonic before and after compensation, students can fully understand the compensation effect of reactive power and harmonic compensation devices.

(3) Based on the measuring results, students can diagnose the deficiencies of the campus power distribution system in energy saving, loss reduction and power quality improvement, and then propose an improvement plans or management measures for the campus power distribution system.

It is worth pointing out that the real-type experiments must be carried out under the supervision and guidance of the campus electrical engineer, must be carried out with standardized operation, and put personal safety and electricity safety first all the time. Through the on-site demonstrative experiments, students can feel the preciseness, standardization and professionalism of power quality evaluation. Fig. 3 shows a photograph of on-site power quality measurement with an advanced power analyzer under the explanation of teacher.

Figure 3. Power quality test in low-voltage distribution substation.

IV. Results of the Campus Power Distribution System Assisted Teaching

During the three years of the epidemic, we carried out the application practice of campus power distribution system assisted teaching of Power Supply Technology, and achieved the following results:

(1) The predictability and efficiency of practice has been significantly improved. During the epidemic period from 2020 to 2023, the practice in the campus power distribution system have been carried out normally, and different forms of practice activities in campus power distribution system have been carried out in coordination with the content and progress of the course teaching. At the same time, the practice in campus has avoided the traffic strain and traffic safety risks, and saved travel time and teaching funds.

(2) The students' learning enthusiasm and efficiency has been significantly improved, due to the close cooperation between the on-site practice in the campus and the course teaching content in the process. For example, when learning the chapter of power quality, we led students to visit the power distribution system of their teaching building, and analyzed the structure, function, and working principle of the two actually installed power quality controller, the switched capacitor bank for reactive power compensation and the active power filter for harmonic mitigation. The students were guided to analyze the problem through the abnormal noise from the device heard on site. At the same time, through the test of advanced power analyzer and the switching of capacitors with different banks, it was confirmed that the noise originated from the harmonic amplification of capacitors. The theoretical analysis of the textbook was linked with the actual system test and the on-site experience, which improved the students' ability to analyze the complex engineering problems. The students said that this kind of immersive analysis of on-site practical problems greatly stimulated their enthusiasm for learning and love of electrical engineering.

(3) The means for students to design and demonstrate power distribution system schemes has been enriched, and students' ability to use modern tools to solve complex engineering problems has been improved. After the introduction of computer digital simulation in classroom teaching, students can consciously use simulation tools in the course design of power supply technology to accurately analyze and evaluate the technical and economic performance indicators of different design schemes. For example, the voltage loss and power loss of power distribution systems under different design schemes are compared through simulation.

The students' objective understanding of electrical components, equipment and systems and their actual feelings of on-site working scenes has been enhanced. The students recognize the connection between what they learned in the course and practical application, and preliminarily understood the professional ethics and norms of electrical engineering.

V. Conclusion

Campus facilities serve for talent cultivation and are the stakeholders of teaching activities, which can play a unique auxiliary role in the teaching of related courses. Taking the teaching of power supply technology as an example, this paper illustrates the position, role, and utilization mode of campus power distribution system in the teaching of power supply technology. By visiting the campus central substation, taking the campus power distribution system as a case study, and using the campus substation as a real-type experiment laboratory, we can comprehensively assist and promote theoretical teaching in the teaching content and teaching process, and enhance students' interest in and effect on power supply technology.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Xiangqian Tong conducted the research and wrote the paper; Feng Ni and Haiyan Wang co-conducted the research and reviewed the paper; Zhongmei Pan, Qian Wang, and Jiandong Duan put forward suggestions for improvement of the paper; Xiangqian Tong and Jiandong Duan provided funding for this research; all authors had approved the final version.

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