# MODERN PRACTICE TEACHING MODEL FOR STUDENTS MAJORING IN ELECTRICAL AUTOMATION TECHNOLOGY

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Digital Technology Management for Education
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# ABSTRACT

The purposes of this research are 1) to study employers' practical skills requirements for electrical automation technology graduates, 2) to design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College, and 3) to evaluate of the effect the modern practice teaching model of electrical automation technology major. The population for this research was 64 human resources executives of enterprises where the students majoring in electrical automation technology are employed and 40 students majoring in electrical automation technology. The sample for this research was 40 human resource executives and 20 students. The research instruments for the first and second phases of this study were questionnaires, and the research instruments for the third phase were pre- and post-tests and comparative tests.

The research results are as follows. Through employer surveys, they have identified the 9 professional practical skills that students majoring in electrical automation technology need to master the most. Afterwards, a modern practical teaching mode was designed for students majoring in electrical automation at Guangxi Vocational and Technical College. This teaching model has been unanimously recognized by 24 experts from five different fields. A pre-test experiment was designed for this teaching mode, with the experimental group using modern practical teaching mode and the control group using traditional teaching mode. For students majoring in electrical automation technology, after training in modern practical teaching mode, their practical ability score has increased by 68.19%, which is 19.39% higher than that of students trained in traditional teaching mode.

**Keywords:** Modern Practice, Teaching Mode, Practical Ability, Electrical Automation Technology

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Ming Xin

# Contents

# Contents (Continued)

# List of Figures

**Figure** **Page**

# List of Tables

# List of Tables (Continued)

**Table** **Page**

# Chapter 1
# Introduction

## Rationale

China's Ministry of Industry and Information Technology and the Ministry of Finance (2016) jointly formulated a development plan for China's intelligent manufacturing industry, clearly proposing that China implement a "two-step" strategy to promote the development of intelligent manufacturing by 2025. In the first step, by 2020, the development foundation and supporting capacity of intelligent manufacturing will be significantly enhanced, and digital manufacturing will be basically realized in key areas of traditional manufacturing; in the second step, by 2025, the support system for intelligent manufacturing will be basically established, and key industries will initially realize intelligent transformation.

Guangxi Province has also issued corresponding policies, clarifying the development goals of Guangxi in the field of equipment manufacturing. Guangxi is in urgent need of technical personnel in the manufacturing fields such as programming, operation, installation, commissioning, maintenance, and design(The People's Government of Guangxi Zhuang Autonomous Region, 2021).

The electrical automation technology major plays a very important role in China's industrial upgrading, and undertakes the task of cultivating outstanding graduates for industrial transformation and upgrading (Zhao Huanli et al., 2020). At present, employers urgently need a large number of electrical automation graduates with high professional practical skills to support industrial upgrading.

The electrical automation technology major of Guangxi Vocational and Technical College was established in 2002. After nearly 20 years of construction and development, this major has accumulated some experience in the cultivation of skilled personnel (Lu Yongwei, 2014). With the adjustment of China's industrial structure in recent years, the requirements for the practical skills of graduates majoring in electrical automation technology have been continuously improved. At present, this major faces some difficulties in the cultivation of students, mainly including three problems:

First of all, due to the continuous application of new technologies, employers have higher and higher requirements for the practical skills of graduates. Secondly, graduates hope to master higher skills through school training, so as to find a high-paying job; thirdly, the school also hopes to send more graduates to employers to assume more social responsibilities.

The modern practice system is already one of the currently internationally recognized teaching models in vocational colleges, and it has been widely used in manufacturing powerhouses such as Germany, the United Kingdom, and Australia(Steedman, H. 2012). Some majors in some higher vocational schools in China have also carried out pilot projects of the modern practice system, and achieved good results.

Therefore, carrying out research on the modern practice teaching model for students majoring in electrical automation technology can effectively solve the problems encountered in the current student training process of electrical automation technology majors in Guangxi Vocational and Technical College. Make the students trained to adapt to the current development of China's economy.

## Research Questions

1. What are the professional practical ability requirements of employers for students majoring in electrical automation technology of Guangxi Vocational and Technical College?
2. How to design a modern practice teaching model for students majoring in electrical automation technology?
3. How to evaluate the modern practice teaching model of electrical automation technology major?

## Objectives

1. To study employers' practical skills requirements for electrical automation technology graduates.
2. To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.

3. To evaluate of the Effect the modern practice teaching model of electrical automation technology major.

## Research Hypothesis/ Hypotheses

The modern practice teaching model has been promoted in many countries around the world, and it has been proven that this teaching model can improve students' overall quality. In China, some vocational colleges have also promoted the modern practice system as a teaching model in some majors, and have achieved certain results. Based on this, it is assumed that the implementation of modern practice teaching model has a promoting effect on improving the practical skills of students majoring in electrical automation technology.

## Scope of the Research

**Population and the Sample Group**

**Population**

The research group of this thesis includes two parts: the human resources executives of enterprises where the students majoring in electrical automation technology are employed and 40 students majoring in electrical automation technology.

Human resources executives include 62 people, and students majoring in electrical automation technology from Guangxi Vocational and Technical College have worked in their companies.

The number of students enrolled in the electrical automation technology major is 40, which are divided into 2 classes, that is, Electrical Automation Technology 1 and Class 2, and the number of students in each class is 20

**The Sample Group**

Sample group of corporate human resource executives: 40 human resource executives were randomly selected as samples from 62 different companies, including 24 from Guangxi Province,7 from Pearl River Delta region,3 from Yangtze River Delta region and 6 executives from Other regions.

The student sample group is Group A: 20 students from class 2 of the electrical automation technology major were selected as experimental samples by random sampling method.

**The Variable**

Independent Variable

Teaching model based on modern practice

Dependent Variable

Professional practical skills of students majoring in electrical automation technology

**Contents**

1. Carry out research on employers who accept graduates of electrical automation technology to clarify the types of jobs and the requirements for students' practical skills for each job.

2. Based on the practical skills requirements proposed by the employer, form an expert team to design a modern practice teaching model.

3. Evaluation of the effectiveness of modern practice teaching model is effective in enhancing students' professional practical abilities.

**Time**

The time frame of the study is from September 2022 to June 2024. This period of time happens to be a complete teaching cycle of the modern practice teaching model implemented in the electrical automation technology major.

## Advantages

For students: The implementation of modern practice teaching mode can improve their practical abilities, enhance their employment competitiveness, and ultimately increase their income.

For schools: The modern practice teaching model can improve the quality of teaching, increase student recognition of the school, and praise the school by society.

For enterprises: The implementation of modern practice teaching mode can enable students to quickly transform into employees, reduce the training cycle for employees, lower management costs, and improve efficiency.

## Definition of Terms

**Electrical Automation Technology Major**

Electrical automation technology is a specialist major in ordinary colleges and universities, which belongs to the automation major, and the basic length of study is three years.

This major cultivates high-quality technical talents who are familiar with relevant national standards and process specifications of drive technology, bus control technology and electrical technology, master basic knowledge of electrical and electronics, instrumentation, programmable control, configuration control, etc., have the ability to operate and manage automation equipment and systems, and engage in installation, commissioning, maintenance, design and operation management of automation equipment and systems.

**Professional Practice Skills**

Professional practical skills is the job responsibility requirement for a certain professional position, and it is a necessary condition for being competent for a certain professional position. It is the basis for the development and creation of a student's career, and is an indispensable basic factor for successfully completing a certain task or being competent for a job. Without ability or low ability, it will be difficult to meet the requirements of the job and be incompetent. The stronger the professional practice ability of students, the more they can promote the creation and development of individuals in professional activities, the more they can achieve better work performance and achievements, and the more they can bring individuals a sense of career accomplishment.

**Apprenticeship**

The International Labor Organization defines apprenticeship in the "Apprenticeship Development Recommendations" as: "During the period specified in the agreement, the employer hires young people and conducts systematic training for them in a certain industry". Later, in the "Vocational Training Development Suggestions", apprenticeship is defined as: "Long-term systematic training in a certain occupation. According to the cooperation agreement, this training is undertaken by enterprises or craftsmen. Enterprises and craftsmen jointly abide by the agreement and follow the established regulations." In these two paragraphs of the definition, special emphasis is placed on the length of apprenticeship and the established agreements and regulations.

**Modern Apprenticeship**

Modern apprenticeship is an educational model jointly promoted by employers and schools, and its educational objects include both students and enterprise employees. For them, schooling means employment, part of the time is in the production of enterprises, and part of the time is studying in school. Therefore, both students and employees can receive corresponding wages from enterprises. As a new model, enterprises and schools need to formulate corresponding policies to support it in its promotion. Modern apprenticeship has the following characteristics: dual identities of student and apprentice, reconstruction of curriculum system and curriculum content, alternation of work and study, school teacher and enterprise master team, and multiple evaluation mechanisms.

**Teaching Model**

Teaching model can be defined as a relatively stable structure framework and activity program of teaching activities established under the guidance of certain teaching ideas or teaching theories. As a structural framework, it highlights the teaching model's grasp of the overall teaching activities and the internal relationships and functions among various elements; as an activity program, it highlights the orderliness and operability of the teaching model.

**Highly Skilled Personnel**

High-skilled personnel refer to those who work in the front line of production, transportation and service fields, who are proficient in specialized knowledge and technology, have superb operational skills, and can solve operational problems in key technologies and processes in work practice. Under the background of vigorously advocating the improvement of independent innovation capabilities of enterprises and the construction of an innovative country, more and faster training of high-skilled talents is regarded as a strategic measure for China to enhance its national core competitiveness.

**Effect Evaluation**

A quantifiable method has been designed for evaluating the practical abilities of students majoring in electrical automation technology, and comparative experiments have been conducted to test whether the modern practice teaching mode has a significant effect on cultivating students' practical abilities.

## Research Framework

The practical ability of students majoring in electrical automation technology is the core element. Through the questionnaire survey of employers, the specific requirements for students' practical skills in different positions of enterprises are clarified. On this basis, a modern practice teaching model is constructed according to the principle of joint development between schools and enterprises. The students in the experimental group and the control group were trained through the MAT teaching model and the traditional teaching model respectively. Through the comparison of pre-test and post-test data, the influence of MAT teaching model on students' professional practical skills is studied. The research framework is shown in Figure 1.1:

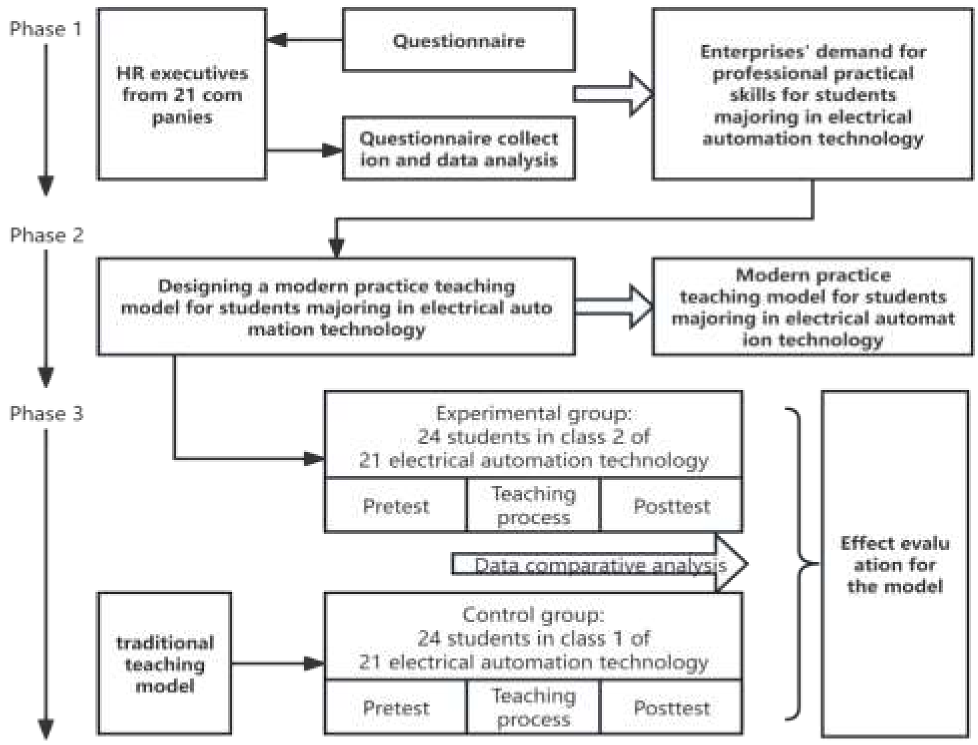


**Figure 1.1** Research Framework

# Chapter 2

# Literature Review

This research focuses on the research on the modern practice teaching mode of electrical automation technology major, and consults the relevant literature at home and abroad. This chapter will do a literature review from the two aspects of "modern apprenticeship" and "teaching model". Through the search and analysis of relevant domestic and foreign literature, it is found that there are some researches on modern apprenticeship and teaching model in foreign countries, but there is almost no research on "modern apprenticeship in electrical automation technology".

Through the research of domestic and foreign literature, this chapter aims to define two concepts clearly:

1. Conceptual Research on Modern Apprenticeship
2. Research on the Concept of Teaching Model
3. Related Research

The details are as follows:

## Conceptual Research on Modern Apprenticeship

### The Concept of Modern Apprenticeships

The report of the World Labor Organization (ILO) defined "apprenticeship" as: "any system" in which employers hire and train young people, and young people serve employers within an agreed period of time. In 1962, the definition of apprenticeship by the World Labor Organization did not mention "young people", but defined apprenticeship as a "long-term systematic training for a certain position under the guidance of a certain company or independent craftsmen under the guidance of a written contract and established standards". That is, apprenticeships are considered a form of training, long-term training according to job-specific criteria.

In 2008, the European Vocational Training and Development Center defined apprenticeship as: "systematic, long-term training that alternates between workplaces and educational institutions or training centers; apprentices are associated with employers through contracts and receive corresponding wages or subsidies; employers are responsible for providing trainees with training for specific positions". Obviously, this definition regards the established contractual relationship between the employer and the apprentice as a necessary condition for the establishment of apprenticeship.

In 2010, Eurostat stated that apprenticeships are aimed at completing a given education and training project in the formal education system, and proposed six criteria for the definition of the concept of apprenticeship: (1) apprenticeship is an integral part of formal education; (2) a qualification certificate can be obtained after the completion of the apprenticeship, which can be used as a qualification for a specific position or position group; (3) training contracts or formal agreements signed between apprentices and employers directly or through educational institutions are typical features of the concept of apprenticeship; (4) The apprentice is paid; (5) the contract period or formal agreement is for a period of at least 6 months and a maximum of 6 years; and (6) in most cases there are no other formal arrangements between the employer and the apprentice to whom the apprenticeship contract or formal agreement relates before the apprenticeship begins. The above standards have relaxed the restrictions on the conditions for the establishment of the contractual relationship between the enterprise and the apprentice. It is believed that the relationship can be established in the form of a "formal agreement" instead of a contract. From this point of view, this definition is much looser than the definition of apprenticeship by the European Center for Vocational Training and Development. At the same time, the definition retains "apprentice remuneration", but does not clearly define the specific apprenticeship period, which still needs to be discussed.

There are also views that the use of keywords such as "learning" and "acquisition" in the definition of apprenticeship reveals that vocational education has lower academic expectations than general education, and also reflects that apprenticeship is a teaching model based on skill learning. That is, apprenticeships are a model of learning.

Since the 21st century, different countries have implemented their own apprenticeship reforms according to their actual conditions, and the traditional apprenticeship has been given a new name. Such as the "registered apprenticeship system" in the United States, the "three-way system" in Switzerland, and the "new apprenticeship system" in Australia.

In 2015, the UNESCO International Center for Vocational and Technical Education and Training (UNESCO-UNEVOC) defined modern apprenticeship as "a unique form of vocational education that combines post-based learning with school-based learning through specifically defined competencies and work processes in the conference report "Vocational Education and Training through High-Quality Apprenticeships". Apprenticeships are governed by laws, standard social security schemes, and written employment contracts. Apprentices get a formal evaluation and a recognized certificate"

Regarding the modern apprenticeship system, China’s Baidu Encyclopedia gives the definition that "the modern apprenticeship system is a modern talent training model that focuses on skills training for students through in-depth cooperation between schools and enterprises, teachers and masters jointly teach students. Different from ordinary junior college classes and the previous talent training models of order classes and title classes, modern apprenticeship systems pay more attention to the inheritance of skills. Schools and enterprises jointly lead talent training. Standardized corporate curriculum standards, assessment plans, etc., reflect the deep integration of school-enterprise cooperation. " This mainly strengthens the inheritance of skills and the depth of cooperation between schools and enterprises.

To sum up, although the concept of "modern apprenticeship" is not completely equivalent to "apprenticeship", it is not a negation of "traditional apprenticeship", but an inheritance and development of the latter. Although there is no unified definition at home and abroad, all explanations about "modern apprenticeship" include elements such as "apprenticeship", "labor remuneration" and "technology inheritance".

**Research on the Development Process of Modern Apprenticeship in China**

Apprenticeship has been developed in China for thousands of years. As a special form of vocational education, apprenticeship has evolved along with China's social and economic development. Chinese scholars have done a lot of related research on the development process and evolution history of apprenticeship. The specific research situation is as follows:

In ancient China, the apprenticeship system was called artist apprenticeship and worker apprenticeship according to different industries. It was an early form of vocational education in China.

Liu Xiao (2011) studied the development process of ancient Chinese apprenticeship from primitive society to slave society to feudal society, and summarized the characteristics of apprenticeship in each historical stage. She believes that vocational education in primitive society is closely connected with the labor process, mainly to teach life skills; after entering the slave society, class differentiation led to vocational education gradually breaking away from the scope of the family, and passing on skills to people outside the family through a primary and incompletely institutionalized apprenticeship system; after entering the feudal society, an apprenticeship system organized at the government level appeared.

China's exploration of modern apprenticeship has never stopped, although it was not named after "modern apprenticeship" in the early days.

Xu Guoqing (2018) Said that after the founding of New China, the private apprenticeship system led by guilds and chambers of commerce turned to government-led vocational and technical schools. A number of vocational training centers have also been incorporated into the national education system through state incorporation and transformation. The country's apprenticeship system has experienced three periods from the beginning of the founding of the People's Republic of China to the reform and opening up, from the reform and opening up to the launch of the modern apprenticeship reform project, and from the launch of the modern apprenticeship reform project to the present. From the beginning of the founding of the People's Republic of China to the reform and opening up, it can be subdivided into: the rapid development in the 1950s and 1960s, and the adjustment in the 1970s and 1980s. After entering the 21st century, the modern apprenticeship system has entered a new period of development in our country.

China promulgated the "Instructions on Carrying out Amateur Education for Employees", which clarified that enterprises can train employees in the form of signing master-apprentice contracts, continuing some practices of the traditional apprenticeship system, and improving the treatment of apprentices on the basis of eliminating the exploitation of employees by the capital side that existed in the apprenticeship system in the old society, so that mentors and apprentices formed an equal and cooperative relationship. The "Provisional Regulations on the Duration of Apprenticeships and Living Subsidies in State-owned, Public-Private Joint Ventures, and Self-Employed Enterprises and Institutions" clearly stated that the duration of apprenticeships should generally be 3 years, with a minimum of no less than 2 years. In the process of training, the enterprise apprenticeship system has formed a technology transfer process of "the master does it, the apprentice looks at it - the master guides it, the apprentice does it - the apprentice works independently - the apprentice masters the skills proficiently". This new type of apprenticeship system within enterprises was basically established and became the training method for training the largest number of reserve skilled workers. It was also called "factory apprenticeship system" by some scholars.

In recent years, vocational schools began to explore a new model of vocational and technical personnel training of "opening the door to run schools, school-run factories, and factories with majors". The state issued the "Notice on Further Improving the Work of Technician Training", and a number of newly established technical colleges began to enroll students on a large scale, and the main body of running schools was changed from enterprises to schools. This period was also a period of rapid development of vocational schools. The scale of running schools remained basically stable, and the number of vocational colleges increased slowly. In addition to technical colleges, a number of ordinary middle schools were changed to vocational technical secondary schools and vocational high schools. A number of undergraduate schools were restructured into higher vocational schools. The Guangxi Vocational and Technical College, where the sample of this research is located, was restructured into higher vocational schools in 1998.

In the 21st century, China's vocational education has entered a period of rapid development, constantly exploring various talent training models. Until 2010, Xinyu City, Jiangxi Province, China promulgated the "Vocational Education Modern Apprenticeship Pilot Work Plan", which is the earliest record in China to explicitly propose "Modern Apprenticeship" in the field of vocational education. The success of the pilot work of modern apprenticeship in Xinyu City quickly attracted the attention of the vocational education field in China.

On February 26, 2014, Premier Li Keqiang presided over the executive meeting of the State Council, determined the tasks and measures to accelerate the development of modern vocational education, and proposed "to carry out the modern apprenticeship pilot program of joint enrollment and training between schools and enterprises". The "Decision of the State Council on Accelerating the Development of Modern Vocational Education" made specific requirements for "carrying out the pilot project of the modern apprenticeship system of school-enterprise joint enrollment and joint training, improving support policies, and promoting the integration of school-enterprise education", marking that the modern apprenticeship system has become an important strategy for the development of national human resources. (General Office of the State Council (Ed.) 2014 )

In August 2014, the Ministry of Education issued the "Opinions on the Pilot Work of the Modern Apprenticeship System" and formulated a work plan.

In July 2015, the Ministry of Human Resources and Social Security and the Ministry of Finance jointly issued the "Notice on the Pilot Work of the New Enterprise Apprenticeship System", which made arrangements for the enterprise-led apprenticeship system. The National Development and Reform Commission, the Ministry of Education, the Ministry of Human Resources and Social Security, and the National Development Bank jointly issued the "Pilot Program for Dual Cultivation and Reform of Technical and Skilled Talents in Old Industrial Bases". The core content is also school-enterprise cooperation to educate people.

In August 2015, the Ministry of Education selected 165 units as the first batch of modern apprenticeship pilot units and industry pilot units. the

In August 2017, the Ministry of Education identified the second batch of 203 modern apprenticeship pilot units. the

In March 2018, the second batch of 203 units selected by Minister of Education Chen Baosheng to "strive to make every child enjoy a fair and quality education" carried out pilots, 366 of which were called modern apprenticeship pilots. (People's Daily Client. 2018)

In May 2019, the General Office of the Ministry of Education issued the "Notice of the General Office of the Ministry of Education on Comprehensively Promoting the Work of Modern Apprenticeships", marking the country's entry into the stage of comprehensive promotion of modern apprenticeships.

Overall, apprenticeship has a long history in China and occupies an important position in the vocational education system. The modern apprenticeship system has evolved continuously with the development of China's economy and society, especially in the past 10 years, it has been developed at a high speed and has been fully promoted in higher vocational colleges.

**Research on the Development Process of Modern Apprenticeship Abroad**

Apprenticeships in England can be traced back to medieval craft guilds. Li Yuexing (2017) explored the functions of guilds in three aspects of economic, political and social life in the paper "Research on the Functions of Guilds in Medieval England (1100-1400)". He believed that the guild form was the source of British modernization and laid the foundation for the transformation of medieval cities. Xia Panpan (2016) studied the important role of handicraft guilds in London's urban social and economic life in the paper "Research on London Handicraft Guilds in the Late Middle Ages". He believes that the establishment of guild apprenticeship and management system is the main reason why the handicraft industry has been active in London's urban economic activities for a long time;

The first national apprenticeship system in England was the Statute of Artificers in 1563. Apprenticeships were abolished in 1814 due to their widespread popularity. However, until the early 20th century apprenticeships remained popular in industries and occupations that valued practical skills, and gradually spread to emerging industries such as engineering, shipbuilding, plumbing and electrical; by the mid-1960s apprenticeships in Britain reached unprecedented scales, with about a third of boys aged 15-17 leaving school to enter apprenticeship factories.

In 1993 the government announced a new apprenticeship scheme called "Modern Apprenticeships". The scheme clearly states that Modern Apprentices can be counted as employees and receive wages where there is a written agreement between the employer and the apprentice. In 1996, the United Kingdom began to implement "National Traineeships". The national training curriculum starts at Level 2, which is equivalent to General Certificates of Secondary Education (GCSEs). The introduction of these courses opens up a pathway to apprenticeships for young people who are not yet ready to enter a tertiary course. The modern apprenticeship system continues to develop with the development of the "national trainee system", the former develops into "advanced modern apprenticeship", and the latter develops into "basic modern apprenticeship". In 2004, Advanced Modern Apprenticeships were called "Advanced Apprenticeships", while Basic Modern Apprenticeships were simply called "Apprenticeships", which were later renamed "Intermediate Apprenticeships".

The development of modern apprenticeships in Germany began after World War II. During World War II, Germany suffered a lot of economic losses. After the war, in order to quickly recover and develop the economy, Germany gradually formed a vocational education system featuring the "dual system" in the field of education. The "dual system" is a new apprenticeship system that closely combines school education and job training. Germany's "dual system" focuses on the combination of school education and corporate training, realizing the intercommunication of education and training, effectively cultivating a large number of practical technical and skilled talents, and laying a good foundation for the rapid development of Germany's manufacturing industry and economy. This is considered to be an important reason for Germany's economic take-off.

Since then, some countries have begun to learn from the German "dual system" model to develop vocational education, and various types of apprenticeships have emerged during this period. Guan Jing proposed in "Characteristics and Enlightenment of Western Modern Apprenticeships" that Hilary Steedman divided

European apprenticeships into demand-guided and supply-guided. Germany, Austria, and Switzerland are countries dominated by demand-led apprenticeships, referred to by the Canadian Center for Living Standards Studies (CSLS) as the Nordic system type. These countries are characterized by high employers' sense of responsibility and clear division of labor and cooperation between enterprises and schools. Countries such as the UK, the Netherlands, Denmark and France implement supply-led apprenticeships. These countries are characterized by low employer accountability and a combination of apprenticeships and full-time educational structures. In addition, countries such as Ireland, Australia, and Canada belong to the Anglo-Saxon system classified by CSLS, which has similar characteristics to the United Kingdom. These countries pay more attention to the development of general education, and pay less attention to vocational education. Enterprises are less willing to invest in vocational training, and training relies more on the principle of individual voluntariness and self-help.

Duo Shujie (2016) believes that the German modern apprenticeship system effectively guarantees the return on corporate education investment by meeting the occupational needs of companies, solving education investment risks, and providing organizational security. Specifically, the apprenticeship system has shown advantages in the following aspects: 1) Human capital is highly specialized and meets the needs of professional positions in enterprises; 2) It solves the dual complementary relationship in education and the credible commitment relationship between apprentices in enterprises, and overcomes the uncertainty of investment; 3) The socially regulated labor market suppresses the externality of investment; 4) The investment cost sharing mechanism makes up for the lack of investment in enterprises; 5) Multi-party participation in governance provides organizational guarantees;

Xu Cong (2014) believes that the dual system in Germany has economic benefits for enterprises. First of all, when the trainees participate in the operation of the enterprise, their work results can bring certain economic benefits to the enterprise. The wages paid by enterprises to trainees are relatively low, which reduces the total cost of vocational education for enterprises. Secondly, vocational education can reduce the cost of recruiting and training new employees for enterprises. In addition to economic benefits, dual systems can also increase the influence of enterprises. First of all, it enhances the society's confidence in the future of the enterprise and enhances the competitiveness of the enterprise. Secondly, it shapes the responsible social image of the enterprise and expands the influence of the enterprise.

Artisans from England, Germany, and other European countries ventured to the New World, bringing forms of the master-student relationship to America. In 1911, the first apprenticeship law in the United States was passed in Wisconsin. The implementation of the Code provides safeguards for apprentices and employers. In 1937 the national apprenticeship law - the Fitzgerald Act - was passed. The Fitzgerald Act established the main form of modern apprenticeship in the United States. The Act not only clarified the labor standards and benefits for apprentices, but also established the Apprenticeship Training Bureau to supervise the registered apprenticeship system in the United States.

Australia's apprenticeship system was established after World War II and was limited to occupations performed by male manual laborers. Formal training in apprenticeships was relatively stable until the mid-1980s. Australian apprenticeships typically last 4 years through a written training contract between the employer and the apprentice. They involve two forms of training: workplace training provided by the employing company or formal training completed at government-run technical and further education colleges (TAFE). Upon completion of training, apprentices become industry-recognized qualified practitioners. In 1992, Australia launched the "Australian Vocational Certificate Training System", and in 1994, apprenticeship and training were incorporated into the system. Over the next few years, the Australian government introduced a series of measures aimed at increasing training and employment opportunities. These include the establishment of a "National Employment and Training Task Force", which has provided substantial financial support. In 1996, the government merged the apprenticeship and training systems to form a unified "new apprenticeship". States have also adopted legislation to strengthen the management of apprenticeships and traineeships. After the implementation of the above measures, the number of trainees has increased and the scope of occupation has been expanded. The number of Australian trainees increased from over 15,000 in 1994-1995 to almost 50,000 in 1996-1997.

Hu Xiujin (2009) on the basis of summarizing foreign modern apprenticeship models, divided them into three main types: one is government-led, the other is enterprise-led; the third is full-time school-led. The apprenticeship system in different countries has different emphases. The UK focuses on the government-led; Germany and Austria focus on the whole-purpose school; while Switzerland and Denmark are in the six phases at the same time, which can continuously promote the reform of the apprenticeship system in their own countries. In the original apprenticeship system. The registered apprenticeship system in the United States is a training method initiated and implemented by employers and in cooperation with community colleges; Switzerland has formed a new three-way apprenticeship training system consisting of vocational education centers, schools and enterprises in combination with its national conditions; Italy began its heavyweight apprenticeship reform in 2003, which is characterized by incorporating apprenticeship into the formal schooling system. Different from the apprenticeship system in other countries, the biggest highlight of Italy's apprenticeship reform is that apprentices have the opportunity and rights to enter higher education in the reformed academic system. Scholar Kuang Ying called it Italy's higher apprenticeship system, which is the highest level of apprenticeship system in history. "

To sum up, the development of modern apprenticeship in different countries is closely related to the economic and social development at that time. Modern apprenticeships in different countries have different emphases and can be roughly divided into three categories: government-led, enterprise-led and school-led. This information provides a broad perspective for the conduct of this study.

## The Concept of Teaching Model

Teaching model is an important concept in the field of education. Scholars at home and abroad have done a lot of research on teaching model, which is expressed as follows:

The meaning of "Model" originates from "pattern", which basically refers to a method of using physical objects as models, and also has the meaning of model and imitation. In Cihai, "pattern" refers to a pattern that can be used as a model, a model, or a variant. In sociology, it is a theoretical schema and an explanation scheme for studying natural or Social phenomenon, as well as an ideological system and a way of thinking. In China's Modern Chinese Dictionary, "Model" is defined as the standard form of something or a standard style that allows people to follow. In the English Chinese Dictionary, "Model" - the word has a model, with various explanations such as prototype, style, model, model, example, style, etc. In the Encyclopedia of International Education, patterns are a necessary process for exploring any field. After determining the variables of a specific outcome or proposing definitions and predictions related to a specific problem, we need to systematically articulate the internal connections between these variables or assumptions to form a hypothetical pattern. This pattern can be established and tested, and can be reconstructed based on further exploration when needed. Although patterns are related to theory and can be derived from it, they are conceptually different from theory (Ding Tingsen. 1990). In the process of understanding things, patterns are forms that can express the relationship between hypotheses and their variables.

Many researchers have different interpretations and functions of "patterns". Qian Xue (2001) described from the perspective of natural science that "a model is a picture created by us through our decomposition of problem phenomena, using the mechanism we have studied, absorbing all major factors, and omitting all non major factors... It is a visualized natural phenomenon." Hu Sen (2003) suggested that "in any field of scientific exploration, when people distinguish various variables based on the degree of influence on specific results, or when defining, explaining, and predicting hypotheses based on specific problems, it is necessary to integrate the relationship between variables and established hypotheses into a hypothetical pattern. Michell (1995) explained the pattern as: By means of categorization that reflects the similarity between things to be understood and phenomena that are being understood or need to be further understood, or by proposing a series of interrelated and restrictive hypotheses to provide auxiliary explanations.

Zha Youliang (2001) made a more comprehensive description of the model from the perspective of scientific methodology. He believed: "The model is an important scientific operation and scientific thinking method. It is to solve specific problems, in a certain abstract, simplification, and hypothetical conditions, to reproduce certain essential characteristics of the prototype object. It is a scientific method as an intermediary to better understand and transform the prototype and build a new object. Starting from practice, through generalization, induction, and synthesis, Various models can be proposed, and the models have been confirmed, that is, it is possible to form a theory; it is also possible to start from the theory, through analogy, deduction, and analysis, to propose various models, so as to promote the development of practice. Models are similar simulations of objective objects (physical models), an abstract description of the real world (mathematical model), and an image display of ideas (image model and semantic model)". Li Shiyan (1994), on the basis of summarizing the relevant definitions of natural science and social science, defined it philosophically: a model is "a simplified description of the cognitive object that people make for a specific purpose." American scholars Bill and Hardgrave, after systematically examining the general meanings of various "models", defined the model as: a model is a theoretically simplified form of representing reality.

Pattern research is a commonly used research method, which has been widely used in the field of modern scientific research. A pattern is a form in which things exist, and things can be understood and grasped from a holistic perspective. By studying patterns, we can better understand the internal structure of things and the relationship between things and other things. Model is not just a style or paradigm, it is also an important scientific operation and scientific thinking method, which provides an effective way for us to understand and solve problems. Model research method is widely used in modern scientific research because of its advantages of brevity, analogy and hypothesis. Through patterns, we can more fully understand the nature of things and gain a deep understanding of how things develop. Pattern studies can also stimulate logical thinking and help us better reflect nature and society. Patterns can be used as a bridge between theory and practice. By constructing patterns, theory and practice can be closely linked, so as to truly guide practical work.

Domestic scholars' research on teaching models has gradually emerged since the 1980s. In the 1980s, there were more than 30 teaching models summarized, including the sublimation of teaching experience and the localized application of foreign models.

Professor Wu Yexian (1998) of Nanjing Normal University is an early domestic scholar who carried out research on teaching models. Based on the relationship structure of teaching subjects, he divided classroom teaching models into three levels from low to high: memory, understanding, and thinking. He believes that the teacher-student relationship in the memory mode is one-way feedback, the teacher-student relationship structure in the understanding model is two-way feedback, and the teacher-student relationship in the thinking model is multi-way feedback.

Professor He Kekang (2000) of Beijing Normal University has carried out research on the teaching model of "leader-subject". Due to the gradual popularization of multimedia and information technology in my country in the 1990s, Professor He took this as a dividing point to divide the teaching model into two types. Before the 1990s, it was a "teacher"-centered teaching model, and "transmitting-accepting" was its main teaching method. After the 1990s, the "student"-centered teaching model was adopted, and "discovery" was its main teaching method. The theoretical basis of the "teacher" centered teaching model is Ausubel's "learning and teaching" theory, and the theoretical basis of the "student" centered teaching model is constructivism learning theory. The "teacher"-centered teaching model places too much emphasis on the leading role of teachers and ignores the main status of students. However, the "student"-centered teaching model pays too much attention to the subject status of students and ignores the leading role of teachers. Therefore, Professor He proposed an eclectic "leader-subject" teaching model, believing that the leading roles of teachers and students can complement each other.

Professor Liu Wei (2008) of Central China Normal University extended the teaching model of "leader-subject" proposed by Professor He Kekang, and proposed to construct a seminar-style teaching model. Professor Liu believes that the key to seminar-based teaching is to establish the dominant position of students in classroom teaching. One of the best ways to put this idea into practice is to organize teaching activities around problems, so that students can participate in the teaching process and stimulate their learning initiative and enthusiasm.

Professor Li Bingde (1994) believes that the teaching model is a relatively stable, systematic and theoretical teaching paradigm formed around a certain theme in teaching activities under the guidance of certain teaching ideas.

Professor Xie Youru (2000) believes that the teaching model refers to the structural form of the stable relationship between the elements of teaching and learning activities and the activity process in a certain environment under the guidance of certain educational ideas, teaching theories and learning theories. This definition highlights three aspects: theory and thought, environment and resources, relationship and structure.

Professor Zhong Zhixian (2001) believes that the teaching model refers to the theoretical construction of ideal teaching activities, and it is a simplified form that describes the structure of teaching and learning activities or the stable relationship between various elements in the process.

Some scholars believe that: "Teaching model refers to the ideological intention and implementation plan of teaching formed under the guidance of certain teaching ideas or teaching theories". The teaching model is "a relatively stable structure and program of teaching activities established under the guidance of certain teaching ideas or teaching theories".

Some scholars believe that the so-called "teaching model" is a relatively stable and simplified teaching structure formed under the guidance of certain teaching ideas and teaching theories, and the elements of teaching activities are based on certain teaching objectives, teaching content and students' cognitive characteristics.

Some scholars believe that: "Teaching model refers to the ideological intention and implementation plan of learning formed under the guidance of certain teaching ideas or teaching theories."

Li Rumi (1996) believes that the so-called teaching model refers to the stable and concise theoretical framework of teaching structure and its specific and operable practical activities formed around a certain theme in order to complete specific teaching objectives and content under the guidance of certain educational ideas and on the basis of rich teaching experience.

Feng Kecheng (1994) believes that the teaching model is "a relatively stable structure and program of teaching activities established under the guidance of certain teaching ideas or teaching theories".

Zhang Xuxiang (2010) and other scholars combined the characteristics of higher vocational education and believed that "the teaching model refers to a certain standard structure and operation model formed by systematically designing the training process according to the training objectives under the premise of determining the educational thought and professional direction".

After 2000, the research on teaching models has become more and more prosperous. For example, Professor Yuan Weixin of Huaiyin Teachers College conducted a detailed discussion on the connotation, approach, supporting conditions and strategies of a new teaching model based on constructivism, "Concept Transformation Learning".

"Teaching Models" edited by Professor Zhong Qiquan in 2002 was the most comprehensive and systematic literature on teaching models at that time. The book used four chapters and 12 chapters to introduce the theoretical basis and implementation methods of ten teaching models in four groups, including teaching models for concept acquisition, teaching models for concept formation, learning and teaching based on concept networks, general problem-solving models, anchored teaching, cognitive models for situational cognition and situational learning, cognitive resilience theory and learning and teaching models based on hypermedia, cognitive apprenticeship teaching models, and learning activity-based learning models. Teaching model and teaching model based on problem situation.

To sum up, Chinese scholars have carried out a lot of research and discussion on the teaching model. No matter what form is used to describe the teaching model, it is inseparable from the two themes of "teacher and students" and "teaching and learning".

In the field of education, scholars generally believe that American scholars Bruce Joyce and Marsha Weil first proposed the concept of "teaching model" in their book "Teaching Model". They believe that the teaching model is a paradigm or plan to guide teaching activities. Bruce Joyce and Marsha Weil believe that "the teaching model is the learning model", and they believe that teachers "when helping students acquire information, ideas, skills, values, ways of thinking and expressions, we are also teaching them how to learn".

Bruce Joyce believes that "excellent teaching is a combination of a series of teaching models", "the classic definition of teaching is the design environment...a teaching model is a learning environment, including the teaching behavior of using this model.", "We evaluate the quality of a teaching model not only by whether it achieves specific goals, but also by whether it can improve learning ability, which is the main purpose."

Wang Wenjing (2000) The teaching model should include the following elements: theoretical basis, teaching objectives, operating procedures, realization conditions, teaching strategies and evaluation. Theoretical basis is the concept of teaching model structure, which is the ideological basis of each teaching model, which provides theoretical support for teaching models; teaching objectives are the core of teaching models, and they are interrelated and point to each other. Instructional models are designed to achieve specific instructional goals, which are expected to produce specific learning outcomes on learners. The teaching objectives determine the operation steps, strategies and evaluation methods of the teaching model; the operation procedure is the time sequence or logical steps of the implementation of teaching activities, and should list the implementation steps of the teaching process and the specific instructions for each step to complete the task; the realization conditions Refers to the various conditions required for the teaching model to achieve the desired effect; teaching strategy refers to the methods, methods and measures used in the entire teaching process; evaluation refers to the evaluation standards and methods of teaching effects, and each teaching model has There should be an evaluation section.

Zhang Wusheng (2000) pointed out that the teaching model is an intermediate link in the application of teaching theory to teaching practice, and it acts as a bridge between teaching theory and teaching practice. Therefore, some scholars believe that "the teaching model has the function of prescription, the characteristics of operability, and the main function lies in application". Some scholars believe that the teaching model has functions in both theory and practice. Functions on the practical side include coaching, anticipating, systemizing, and improving. The guiding function means that the teaching model can provide teaching practitioners with the conditions, steps and activities to achieve the teaching goals; the predictive function means that the teaching model can help predict the expected teaching effect; the systemizing function means that the teaching model can make teaching an organic The improvement function means that the teaching model can improve the teaching process, methods and results, and break through the existing teaching framework as a whole. The theoretical function of the teaching model is mainly reflected in two aspects. First of all, the teaching model can express teaching ideas or theories in a concise way, which is easy for people to understand and use. Secondly, the teaching model is not only a summary and generalization of specific teaching activities, but also has the role of guidance and exploration. Through continuous practice and experimentation, the framework of the teaching model can be more systematic and standardized in theory, providing rich materials for the research of teaching theory. Therefore, the theoretical and practical research of the teaching model has a dual role. On the one hand, it can enrich and develop existing teaching models and teaching theories, and provide educators with more choices. On the other hand, it can also build a bridge between teaching theory and practice, provide guidance and support for educators, and help them better understand and apply the nature and laws of the teaching process. By combining the theory and practice of the teaching model, the practical teaching activities of educators can be made more specific and operable, so as to achieve better educational and teaching effects.

In the study of the theory and practice of education and teaching, we found that the systematic and complete teaching model came into being after the formation of an independent system from modern pedagogy. Chinese educators such as

Confucius and Zhu Xi, as well as the ancient Greek philosopher and educator Socrates, etc., although they have some thoughts related to the teaching model, they can be said to be only the initial formation of the teaching model. The "perception-memory-understanding-judgment" teaching model proposed by the Czech educator Comenius is considered to be the first relatively mature teaching model in the world. Afterwards, Herbart's teaching model of "clarity-union-system-method" and Dewey's "pragmatism teaching model" became models of teaching models in the field of modern pedagogy.

Dell'Olio J M, Donk T (2007), introduces 10 classic and modern teaching models that can provide learning experiences for PK-12 students. In order for readers to have a rich experience with each teaching model, the author analyzes each model from both conceptual and practical aspects. content standards and benchmarks.

Therefore, based on the research results of the above scholars and the teaching characteristics of higher vocational education, the author believes that the so-called higher vocational education teaching model is a relatively stable teaching model designed and constructed to form students' professional ability under the guidance of certain teaching ideas and teaching theories. Structural framework and implementation strategy.

## Related Research

Some domestic scholars have also done relevant research on the practical application of modern apprenticeship in the field of vocational education. The details are as follows:

Tu Wanli (2018) explored the application of modern apprenticeship in mechanical processing and manufacturing, and provided a series of countermeasures for the cultivation of a large number of modern senior professionals in mechanical processing and manufacturing, such as re-establishing the training objectives of mechanical processing and manufacturing professional skills, rationally selecting training content, and implementing a series of talent training mechanisms such as interest-driven mechanisms, management communication mechanisms, course development mechanisms, and evaluation guarantee mechanisms.

Lin Xiaowei (2019) did research on how to cultivate a large number of high-skilled talents in hardware, electromechanical, in order to solve the problem that the number of high-skilled talents in hardware, electromechanical, cannot meet the development needs and restrict the development of many enterprises. He proposed a 6T model for the cultivation of mechanical and electrical high-skilled talents: co-definition of training programs, co-construction of curriculum systems, co-training of teachers, co-management of the teaching process, sharing of school-enterprise resources, and integration of school-enterprise culture. The 6T model meets the development interests of manufacturing enterprises, meets the growth needs of students, and improves the efficiency of running schools.

Shi Yongyang (2019) analyzed the problems existing in the "double tutor" team building of a college in Guangdong, and put forward some suggestions for improving the "double tutor" team building of the modern apprenticeship system. Through incentive measures at the three levels of school-enterprise, industry and government, an institutional environment conducive to the cultivation of the modern apprenticeship "double mentor" team is provided.

Li Qingqing (2013) took a vocational school in Chongqing as a typical case to conduct field research on the implementation of the "modern apprenticeship" in vocational colleges. In the end, it was found that only the in-depth cooperation between schools and enterprises can truly achieve a "win-win" for all parties, and finally give full play to the respective advantages of enterprises and schools to cultivate more high-skilled talents.

Guan Jing (2011), according to the research on the typical characteristics of the German dual system include: system management at the national strategic level, multi-participation stakeholder mechanism, enterprise-based talent training model combining work and learning, and apprentice-based dual system. identity, unified and standardized education and training standards, and integration with the national vocational qualification system. It is proposed that combining the current situation of vocational education development in my country, we can strengthen the vocational education and training of the new generation of migrant workers and learn from the modern apprenticeship system.

Wang Zhenhong (2012) systematically expounded the implementation elements of the modern apprenticeship system from the construction of the school-enterprise cooperation platform, the reconstruction of the learning carrier, the reform of the teaching organization and management model, the goal gathering of the teaching team, and the cultural value orientation of teaching evaluation. From the traditional apprenticeship system to the modern apprenticeship system, it has given new connotations to the "advanced nature" of higher vocational education.

Zhang Qifu (2015) discussed the difficulties faced by higher vocational colleges in the trial implementation of the modern apprenticeship system, including the inadequacy of the specific measures of the government and schools, the failure of industry enterprises and schools to jointly formulate a unified teaching standard for apprenticeship training, and the requirements for apprentices to complete training. There are no clear and unified requirements for the level of knowledge and skills, no unified training content and methods, no evaluation system, etc. Some specific solutions are proposed.

Xie Junhua (2013) affirmed the advantages of the modern apprenticeship system in the cultivation of skilled personnel, and can solve many problems in the current vocational education in a targeted manner. He pointed out that the implementation and development of the modern apprenticeship system requires not only good system guarantees, but also specific work such as curriculum construction in practice.

Lu Wanyu (2023) analyzed the current situation of higher vocational talent training in my country through interviews and surveys, and found out the shortcomings of the current higher vocational talent training model. Based on the advanced experience of modern apprenticeship system in vocational education in Germany, Australia, the United Kingdom, Switzerland and other countries, according to the actual situation of higher vocational education in my country, a modern apprenticeship talent training model with Chinese characteristics is constructed. This teaching model requires the joint support of the government, schools and employers to achieve improvements in the following aspects. Including: combining the education system with the labor system, combining vocational education with vocational training, combining student learning in schools with training in enterprises, combining school graduation certificates with enterprise vocational qualification certificates.

Bi Yan (2014) aimed at what is modern apprenticeship? How to carry out the pilot work of modern apprenticeship? These two issues are studied from the definition and connotation of modern apprenticeship, the construction of modern apprenticeship system, and the strategy of modern apprenticeship pilot. Provide theoretical reference for the government to formulate relevant policies and schools to carry out the pilot work of modern apprenticeship.

Peng Siheng (2015) analyzed the current situation of the modern apprenticeship training model in higher vocational colleges, including the current training objectives, training content and training methods. He discovered the problems in the implementation of the modern apprenticeship talent training model in higher vocational colleges, and proposed countermeasures such as using government-oriented supportive policies, formulating laws and regulations with clear rights and responsibilities for both schools and enterprises, and industry associations assisting in coordination and promoting cooperation and communication. the above problems.

Feng Fang (2016) showed through the research on the modern apprenticeship system in Britain that the reason for its success is the critical inheritance and innovation of the ancient apprenticeship system. The innovation lies in strengthening the leading role of the government, taking the economic demand as the orientation, formulating policies to encourage enterprises to participate in the new apprenticeship activities, flexible and diverse training content and forms, etc.

Zhao Pengfei (2014) started with the characteristics of modern apprenticeship, and made a comparative analysis of the practice of modern apprenticeship at home and abroad. The results show that promoting the modern apprenticeship system in our country is an inevitable requirement of social and economic development, and it is an inevitable trend of the reform and development of vocational education personnel training model. The key points to promote the modern apprenticeship system in our country are: to implement joint school-enterprise enrollment, classified training, school-enterprise joint management, comprehensive evaluation, dual-certificate integration and double-tutor training. It also puts forward seven suggestions for the problems encountered in promoting the modern apprenticeship system.

Zhao Zhiqun (2009) pointed out that the goal of vocational education is to enable learners to acquire the ability to engage in a profession, and professional ability cannot be formed only by theoretical knowledge learning and skill operation training. Vocational learning includes not only the acquisition of knowledge and skills, but also the reflection on work experience. Combining the learning of knowledge and skills with the acquisition of relevant work experience is the common direction of the development of vocational education systems in contemporary countries.

Yang Xiaoyan (2012) studied that apprenticeship as a form of education has dual meanings of technology inheritance and ideological education. Modern apprenticeship is the inheritance and development of traditional apprenticeship, emphasizing experiential learning activities in real work scenarios. Under the background of school-enterprise cooperation, the major of automobile technology in higher vocational colleges explores the modern apprenticeship system with Chinese characteristics from the three links of "accepting apprentices-learning skills-leaving teachers". The main contents include: project-based management model, teacher-student relationship, open learning environment, alternate learning methods, all-round learning content, etc.

Li Chuanwei (2015) studied that "modern apprenticeship" is an important way to cultivate technical and skilled personnel in all countries in the world, and the conditions for implementing modern apprenticeship in our country are already met. The six-point modern apprenticeship school-enterprise cooperation strategy he proposed overcomes the single school The disadvantages of separation of education and practice are conducive to improving students' professional ethics and technical ability.

Xiong Yu (2014) pointed out that the modern apprenticeship system has more advantages than other talent training models in cultivating the technical ability and comprehensive quality of vocational school students. Based on the analysis of the main points of implementing the modern apprenticeship system in my country at the present stage, taking the applied electronic technology major of Zhongshan Torch

Vocational and Technical College as an example, the modern apprenticeship talent training model is explored and practiced. Countermeasures are put forward to solve the problems in the process of implementing modern apprenticeship.

Li Xiang (2015) analyzed the modern apprenticeship training model in higher vocational colleges, which is mainly characterized by the combination of work and learning, affirmed the results achieved in the trial process, and also pointed out some difficulties faced. He pointed out that it is necessary to clarify the tripartite responsibilities of schools, enterprises and students, improve the safeguard measures for the practice of modern apprenticeship, and explore the implementation methods of modern apprenticeship, in order to solve the difficulties in the process of trial implementation of modern apprenticeship in vocational colleges.

Jia Wensheng (2021) used questionnaires and interviews to conduct research, and analyzed modern apprenticeships from the macro-level of the social system, the meso-level of the school-enterprise organization, and the micro-level of the individual. On this basis, it is proposed that the integration of industry and education enterprises should clarify the responsibility of participating in the modern apprenticeship system at a macro level, adopt non-market governance means to stimulate the initiative of enterprises at the meso level, and establish a management system for the selection of enterprise masters at the micro level to construct a new master-apprentice relationship. related advice.

Zhou Zhan (2023) summarized the important achievements and experience of the current modern apprenticeship pilot. Aiming at some problems existing in the teaching model under the previous modern apprenticeship system, he took the "Lens Technology Young Eagle Program Class" as the experimental object, and through the modern apprenticeship education model based on vocational skills, he improved the quality of vocational education personnel training and strengthened the Capabilities in the professional services industry.

Zhu Bin (2023) pointed out that higher vocational colleges should shoulder the important task of cultivating high-skilled talents for social development. This paper analyzes the practical strategy of innovating the modern apprenticeship talent training model of mechanical and electrical majors, introduces the concept of integration of production and education in the teaching of mechanical and electrical majors, creates a more efficient modern apprenticeship talent training model, and improves the training effect of mechanical and electrical majors.

Zhang Wei (2019) studied the two educating subjects of school mentors and enterprise masters in the modern apprenticeship system, and analyzed their respective responsibilities. The corresponding improvement measures are put forward from the aspects of system training, system guarantee, resource flow and industry guidance. The above research provides a reference for promoting the dual-tutor collaborative education model in vocational education under the modern apprenticeship system in my country.

Xiao Yi (2022) studied the cases of promoting the high-level development of modern apprenticeship in British higher vocational education since 2017 by clarifying the responsibilities of the main body of evaluation, formulating apprenticeship standards and norms, and establishing an end-point evaluation system in the United Kingdom. He proposed that my country should adopt The following measures will promote the development of modern apprenticeship: Strengthen the top-level design to clarify the responsibilities of all parties, establish a quality evaluation system, and play the role of the main body of the enterprise.

Zhang Yong (2022) studied that higher vocational education courses are the basis for cultivating high-skilled talents. It needs to be centered on student development, guided by the advancement of professional ability, promote the effective combination of engineering and learning, and systematize work process knowledge. The design of the curriculum system should focus on the job position, so as to realize the reconstruction of professional courses and the deep integration of professional courses and jobs.

H Metcalf, T Anderson(2003) conducted a study aimed at: 1 determining whether to focus on the employer's key work areas; 2 determining the relationship between the quantity and quality of training;3 determining the importance of obtaining and completing qualifications; 4 Survey MAs' opinions and overall satisfaction with exit training and key skills. He Completed a survey on the experience of apprenticeship programs among 1500 modern apprenticeship (MA) employers in the UK. Employers in industries including engineering, business administration, information technology, retail, construction, hospitality, accountancy, travel services, and printing. The results indicate that employers have high satisfaction with MAs, and their participation in training programs and non work training content makes them more willing to continue with this program.

N Murray (2002) discussed the modern apprenticeship scheme launched by the labor/union government in 2000, and conducted in-depth interviews with four industries: electrical, electronic, engineering and agriculture. He outlined the current status of industry training, examined the economic, social, and political background of the policy, outlined the details of modern apprenticeship, and proposed improvement suggestions for certain aspects.

SD Scotland (2013) conducted a telephone survey of 1800 modern apprentices in Scotland, including: how to enter the modern apprenticeship scheme; Income status after leaving MA for six months; Satisfaction with the course; The reason for leaving MA; Career development; The impact of MA on ability. The interviewee left MA about six months ago, and some have already completed their apprenticeship and some have not yet completed it. It provides evidence from a small qualitative Case study that addresses the summative assessment practice of competency based qualifications in the UK automotive industry apprenticeship system.

Alison Fuller (2003) conducted research on the problems faced by the British government since the introduction of modern apprenticeship in 1994, exploring the structure, content, and implementation of modern apprenticeship. The most prominent issue identified is the lack of employer demand and commitment, but the government hopes to expand the modern apprenticeship system to provide opportunities for as many young people as possible. He believes that the government is more concerned about the social inclusion potential of the plan, rather than simply developing a high-quality work based approach.

Paul Ryan (2020) made a comprehensive comparison between the modern apprenticeship programs in the UK and Germany. Although the government has provided a large amount of financial support and improved the skills of apprentices, there are gaps compared to Germany in terms of qualifications, completion rates, and the breadth and depth of training. The conclusion is that in order to play the educational role envisioned by the government for apprenticeship, improvements need to be made from multiple aspects, and suggestions are provided.

Malcolm Greig (2019) analyzed the data of 78952 resignations through a final survey of Scottish apprentices from 2007 to 2015, of which 59737 were completed and 19215 were incomplete. Further research has found that women are more likely than men to complete apprenticeships, but women from impoverished areas are less likely to complete apprenticeships. Apprentices employed by large employers, apprentices trained by public sector organizations, apprentices studying selected technical subjects, and apprentices living in areas with high unemployment rates are more likely to complete their studies. Finally, the impact of this on apprenticeship policies in Scotland and other regions was discussed.

Ashman (2021) studied the visibility of rural and regional students to career paths, the emotional concerns of potential students who choose to receive higher education, and the links between skills and knowledge, and proposed to implement an innovative apprenticeship pilot work. The premise is to complete under the current funding, discipline and systematic framework of the current University system in Australia

Maguire (1998) conducted a study on 500 British employers operating modern apprenticeships and found that 58% were small businesses; 63% only recruited one apprentice; They are very satisfied with their participation; The current favorable economy helps to consolidate modern apprenticeship in training infrastructure.

To sum up, existing studies on apprenticeships have paid more attention to the historical evolution of apprenticeships, national development, and the problems and status quo in mechanism construction and policy reform. In terms of research objects, more focus is on relatively macroscopic research objects such as the education policy of apprenticeship and the school-enterprise cooperation mechanism of apprenticeship, while there are few studies on the teacher-student relationship, learning problems and teaching models in apprenticeship education.

In the current research, there are almost no cases of research on "modern practice of students majoring in electrical automation technology", and there is no research on the satisfaction survey of apprenticeship teaching model. These provide considerable research space for this study, and conduct research on the modern practice teaching model implemented by the electrical automation technology major of Guangxi Vocational and Technical College.

And efforts can be made to advance in the following aspects:

Find out the requirements of enterprises for the practical ability of students majoring in electrical automation technology

Designing a teaching model based on modern practice for students majoring in electrical automation

Multi-dimensional evaluation of the effectiveness of modern practice teaching model.

# Chapter 3
# Research Methodology

In order to find out the modern practice teaching model suitable for students majoring in electrical automation technology, this research mainly uses qualitative research and supplements quantitative research to solve different problems. On the basis of qualitative research, combined with quantitative research methods, it provides support for the reliability and validity of qualitative research.

This study investigates the specific requirements of employers for the practical skills of students majoring in electrical automation technology, and establishes a modern practice teaching model to improve students' professional practical ability. This research is divided into three phases.

**Phase 1** was conducted to answer research **objective 1**: To study employers' practical skills requirements for electrical automation technology graduates.

**Phase 2** was conducted to answer research **objective 2**: To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.

**Phase 3** was conducted to answer research **objective 3**: To evaluate the modern practice teaching model of electrical automation technology major.

The details are as follows:

## Phase 1 Was Conducted to Answer Research Objective 1:

To study the specific requirements of employers for the practical skills of students majoring in electrical automation technology in Guangxi Vocational and Technical College.

The flowchart of the first phase implementation is shown in Figure 3.1

In order to achieve the goals of the first phase, the following steps need to be completed. First, the researcher designed a questionnaire on the elements of practical ability of students majoring in electrical automation technology, and handed the draft of the questionnaire to the consultant for review to ensure its correctness and completeness. Then, five experts conducted item-objective congruence testing on the questionnaire. The researcher requested permission for data collection from the company's human resources managers, and after receiving permission, the questionnaire was distributed to them.

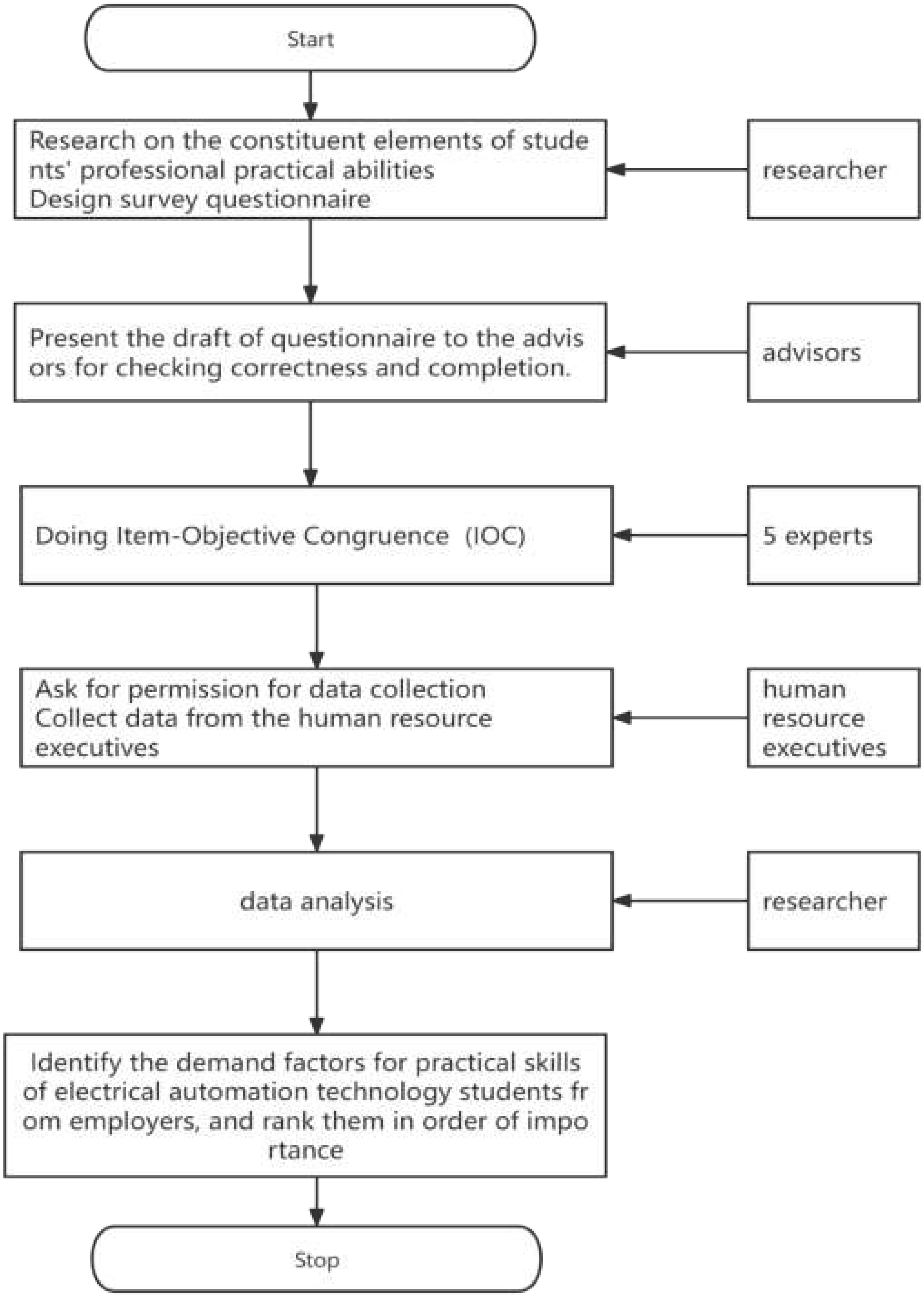


**Figure 3.1** Implementation steps for the phase 1

After collecting these questionnaires, perform data analysis on the questionnaires to clarify the specific needs of employment companies for the practical skills of students majoring in electrical automation technology, and sort these needs in order of importance.

**The Sample**

Sample group of corporate human resource executives: 40 human resource executives were randomly selected as samples from 40 different companies. Students majoring in electrical automation technology are employed in these companies.

24 executives from Guangxi Province

7 executives from Pearl River Delta region

3 executives from Yangtze River Delta region

6 executives from Other regions

**Research instrument**

The questionnaire for human resource executives

**Designing instrument**

1. Research on the constituent factors of practical skills of graduates majoring in electrical automation technology.

2. Design questionnaire for practical skills of students majoring in electrical automation technology in Guangxi Vocational and Technical College.

3. Present the draft of questionnaire to the advisors for checking correctness and completion.

4. Assess the validity of questionnaire on factors about professional practical skills for the students of Electrical Automation Technology Major in Guangxi Vocational and Technical College by 5 experts through Index of Item-Objective Congruence (IOC) according to the criteria shown below.

+1 = Sure that the contents are related to the topics

0 = Not sure that the contents are related to the topics

-1 = The contents are not Guangxi Province related to the topics

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures will be used to ascertain the relevance of each questionnaire question to the study's objectives, ensuring the quality of data collected.

5. Design Likert 5-point rating scale questionnaire on the following score rating criteria.

Score rating criteria

5 means strongly agree or absolutely true

4 means agree or absolutely true

3 means neutral or true

2 means disagree or false

1 means strongly disagree or absolutely false

The factors of professional practical skills of students obtained from the employers are interpreted using MEAN interpretation criteria proposed by Phongsri (2008, p. 1951).

4.51-5.00 means the Highest

3.51-4.50 means High

2.51-3.50 means Moderate

1.51-2.50 means Few

1.00-1.50 means Fewest

**Data Collection**

1. Ask for permission for data collection.

2. Collect data from the assigned human resource executives using the developed questionnaire.

**Data Analysis**

Descriptive Statistics i.e., Frequency, MEAN (), Standard Deviation (S.D.)

**Expected Output Phase 1**

Through the above research, it is concluded that the employers' demand elements for the practical skills of students majoring in electrical automation technology.

### Phase 2 Was Conducted to Answer Research Objective 2:

To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.

The flowchart of the second phase implementation is shown in Figure 3.2

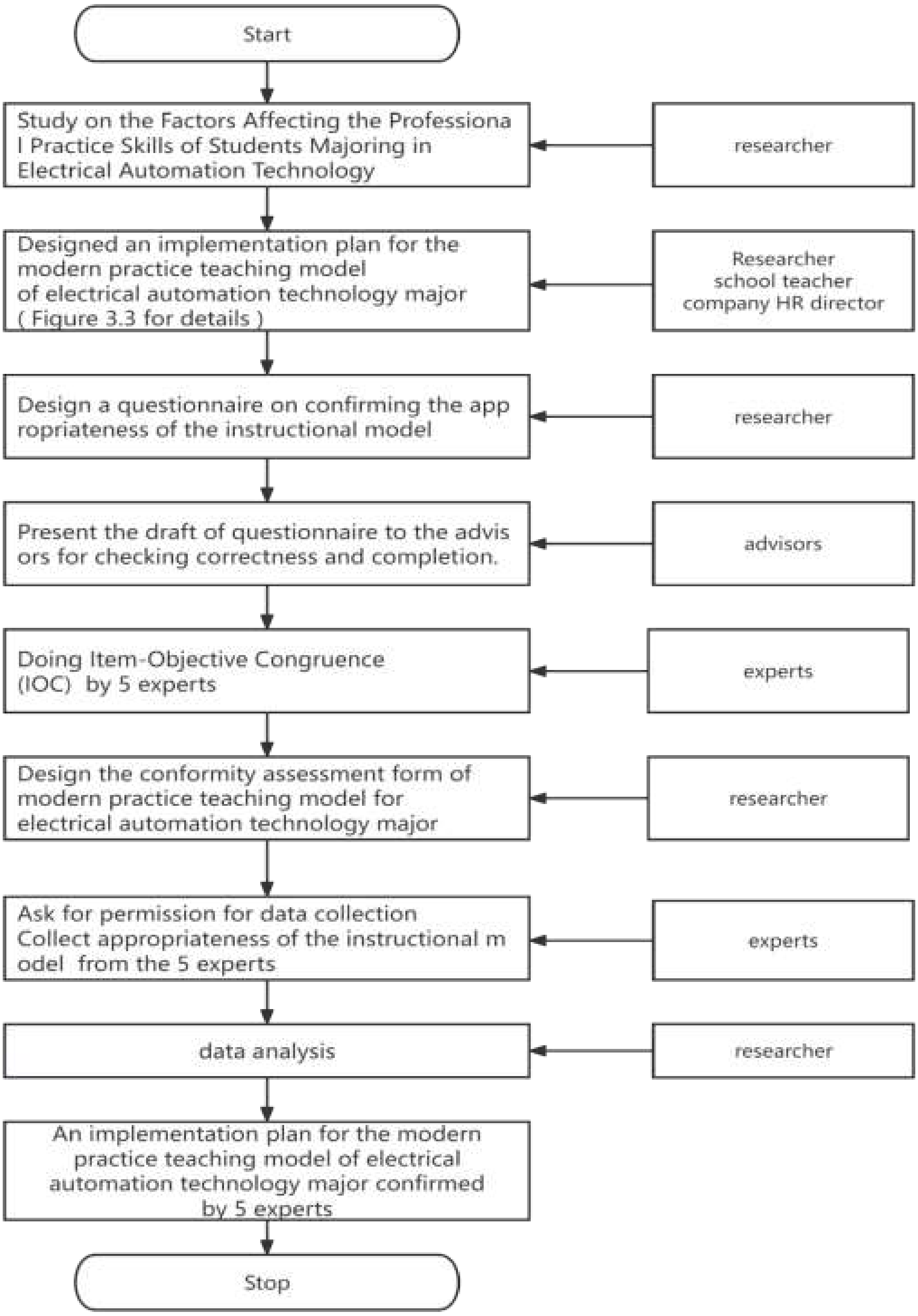


**Figure 3.2** Implementation steps for the phase 2

In order to achieve the objectives of the second phase, the study was carried out according to the following steps. First, the researchers studied the factors that affect the practical skills of students majoring in electrical automation technology. In response to the above research, researchers, school teachers and corporate human resources directors jointly designed an implementation plan for a modern practice teaching model for students majoring in electrical automation technology. The details of the plan are listed in Figure 3.3. Afterwards, design a questionnaire for the above solution to confirm its appropriateness. And submit the draft of the questionnaire to the consultant for review to check the correctness and completeness of the questionnaire. Then, five experts conducted item-objective congruence testing on the questionnaire. Next, a conformity assessment form for the modern practice teaching model in the electrical automation major is designed. After obtaining permission to collect receipts, the suitability of the modern practice teaching model was collected from 5 experts and these collections were analyzed. Ultimately, this research phase will lead to an implementation plan for a modern practice teaching model for students majoring in electrical automation technology.

The design process of the modern practice teaching model for electrical automation technology major is shown in Figure 3.3

The design of the modern practice teaching model is divided into the following stages: curriculum framework establishment, course content planning, and teaching resource construction. The curriculum framework establishment phase is mainly completed by corporate practice experts. Their main job is to convert the practical skills of electrical automation technology students into specific knowledge, thereby determining the curriculum framework. Then, experts formulate curriculum standards and design teaching tasks. Finally, we enter the stage of practice teaching resource planning and design overall requirements for several aspects involved in this teaching model, mainly including three parts of work: teacher team building plan, course resource construction plan, and practical training environment construction plan. Through the above plans, arrange the dual teacher teaching team, specific teaching resources (teaching objectives, teaching methods, teaching implementation process, assessment methods, etc.), and practical training environment in the implementation process of model.

The above content needs to be recognized by engineering practice experts, curriculum development experts, teaching managers, and school teachers, otherwise modifications will be required.

After the above steps, the teaching model of modern practice is developed.

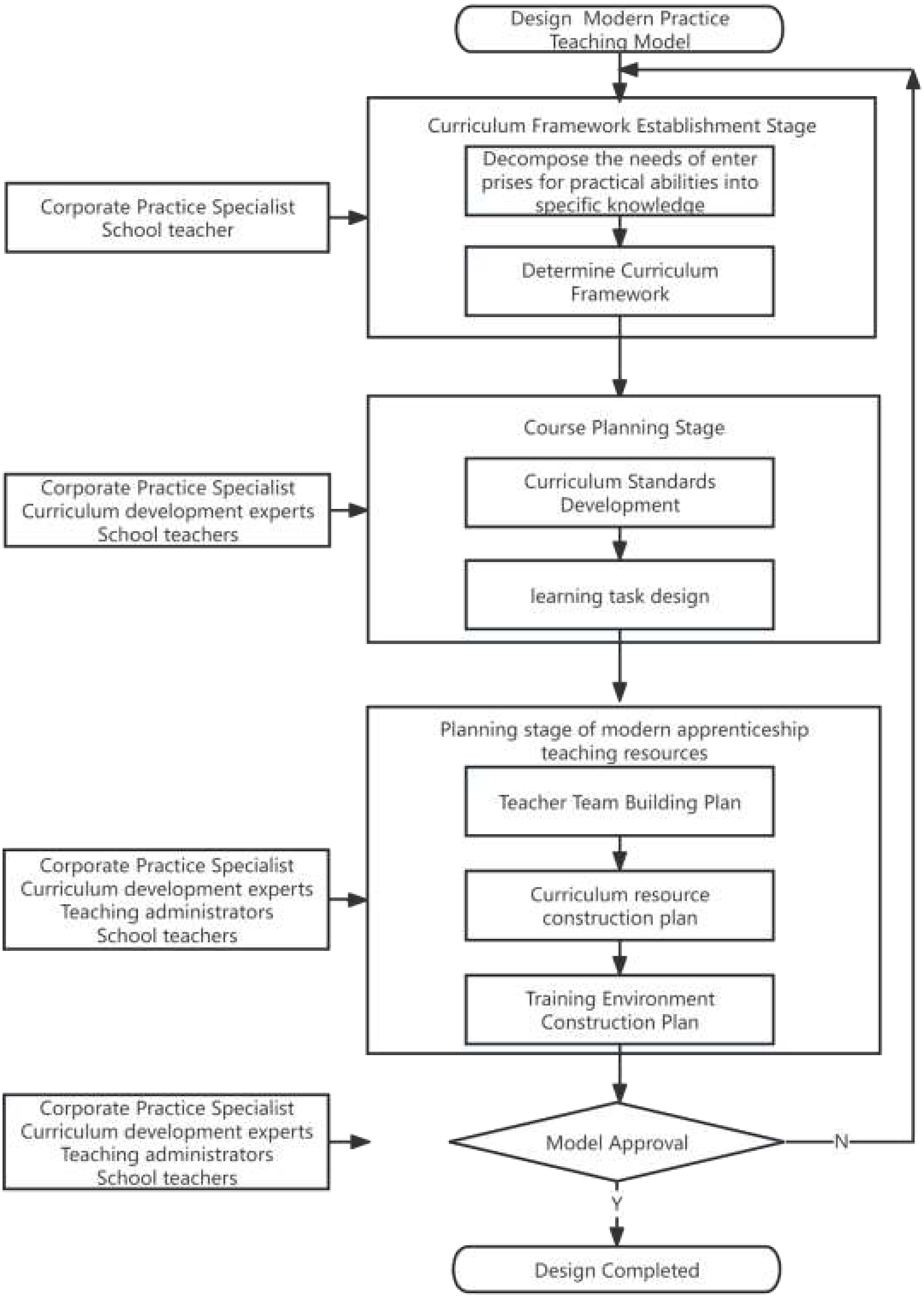


**Figure 3.3** The design process of the model

**The Population**

The Electrical Automation Technology major has 40 students, divided into two classes: Electrical Automation Technology Class 1 and Class 2, with 20 students in each class.

**The Sample Group is Group A:**

Using random sampling method, 20 students from Class 2 were selected as experimental samples.

**Research Instrument**

Conformity Assessment Form of Modern practice teaching model for electrical automation technology major in terms of accuracy standard, propriety standard, feasibility standard, and utility standard.

**Designing Instrument**

1. Study on the Factors Affecting the Professional Practice Skills of Students Majoring in Electrical Automation Technology from Research Objective 1.

2. Designed an implementation plan for the modern practice teaching model of electrical automation technology major.

3. Design a questionnaire on confirming the appropriateness of the instructional model in terms of accuracy standard, propriety standard, feasibility standard, and utility standard.

4. Present the draft of open-ended interview to the advisors for checking correctness and completion.

5. Assess the validity of the questionnaire on confirming the appropriateness of the instructional model by 5 experts through Item-Objective Congruence (IOC) according to the criteria as shown below:

1 = Sure that the contents are related to the topics

0 = Not sure that the contents are related to the topics

-1 = Sure that the contents are not related to the topics

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures the validation measures provides insights into the relevance and coherence of the questionnaire items.

6. Design the conformity assessment form of modern practice teaching model for electrical automation technology major.

**Data Collection**

1. Ask for permission of data collection

2. Collect appropriateness of the instructional model in terms of accuracy standard, propriety standard, feasibility standard, and utility standard from the 5 experts using the developed conformity assessment form of modern practice teaching model for electrical automation technology major.

**Data Analysis**

Descriptive analysis, i.e., frequency and percentage.

**Expected Output Phase 2**

An implementation plan for the modern practice teaching model of electrical automation technology major confirmed by 5 experts.

**Phase 3 Was Conducted to Answer Research Objective 3:**

To evaluate the modern practice teaching model of electrical automation technology major.

The flowchart of the third phase implementation is shown in Figure 3.4

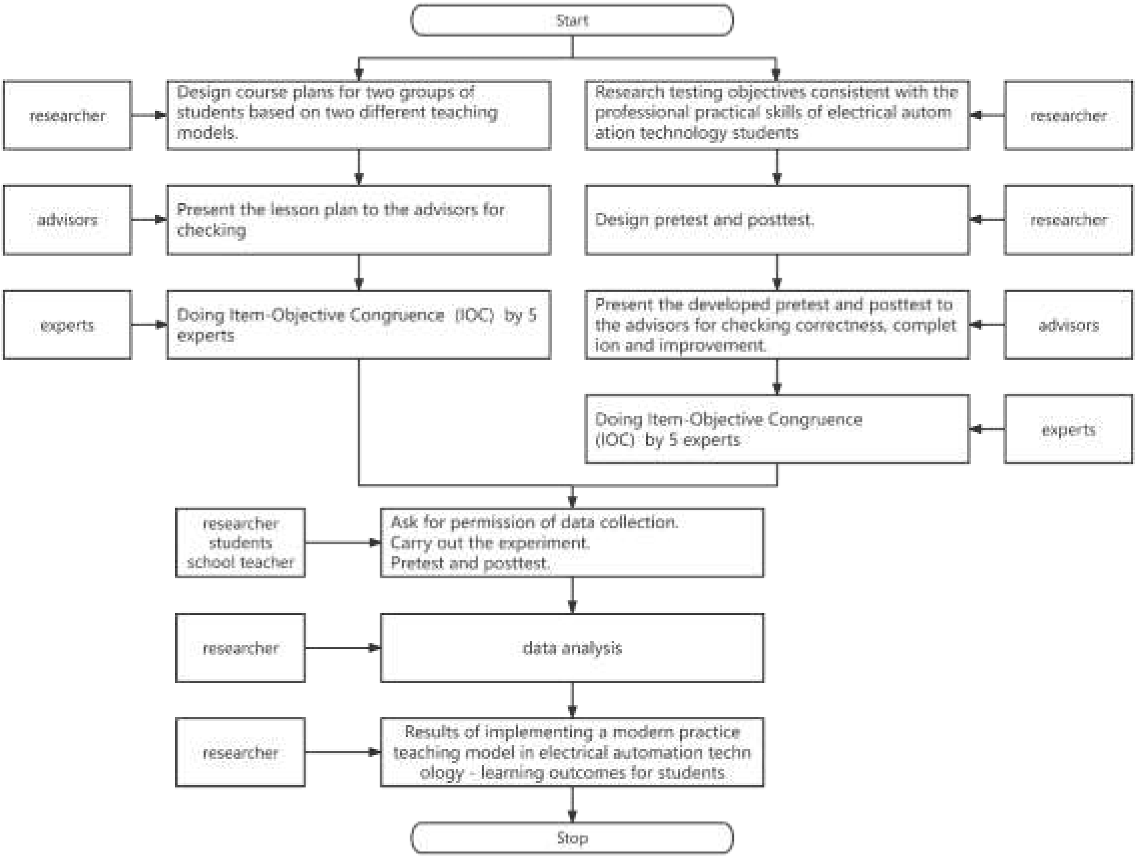


**Figure 3.4** Implementation steps for the phase 3

The third stage of work is to evaluate the modern practice system for students majoring in electrical automation technology. The work in this stage is divided into the following steps. Firstly, different course plans were designed for the two groups of students participating in the experiment based on traditional teaching methods and modern practice teaching methods. Then, the course plans were submitted to consultants for accuracy and completeness. Next, five experts conducted item-objective congruence tests on the above two groups of course plans. At the same time, the following work will be carried out simultaneously to study the evaluation methods of professional practical abilities of students majoring in electrical automation technology, and to design pre and post tests for the two groups of students participating in the experiment. Submit the pre and post test plans for the design to the consultant for verification of accuracy and completeness. Then ask 5 experts to conduct item-objective congruence tests on the pre and post test plans. After completing the above two tasks, the researcher requests permission for data collection and conducts pre and post tests on two groups of students participating in the experiment using different teaching modes. Collect data and draw conclusions from the analysis of this study.

**The Population**

The number of students enrolled in the electrical automation technology major is 40, which are divided into 2 classes, that is, Electrical Automation Technology 1 and Class 2, and the number of students in each class is 20

**The Sample Group is Group A:**

20 students from class 2 of electrical automation technology major were selected as experimental samples by simple random sampling method.

**The Control Group is Group B:**

20 students from class 1 of electrical automation technology major were selected as the control group.

**Research Instruments**

1. Group A used the lesson plan of the modern practice teaching model of electrical automation technology, and group B used the traditional lesson plan

2. Pretest and Posttest

**Designing Instrument**

1. Study contents, objectives, methods of teaching, materials, evaluation and learner assessment methods

2. Design course plans for two groups of students based on two different teaching models.

3. Present the lesson plan to the advisors for checking correctness, completion and improvement.

4. Assess the validity of the designed lesson plans by 5 experts through Item-Objective Congruence (IOC) according to the criteria as shown below:

1 = Sure that the contents are related to the topics

0 = Not sure that the contents are related to the topics

-1 = Sure that the contents are not related to the topics

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures provides insights into the relevance and coherence of the lesson plan content.

5. The sample group uses a modern practice curriculum plan and The control group uses a traditional curriculum plan for comparative testing

**Pretest and Posttest**

1. Research testing objectives consistent with the professional practical skills of electrical automation technology students

2. Design pretest and posttest.

3. Present the developed pretest and posttest to the advisors for checking correctness, completion and improvement.

4. Assess the validity of the designed pretest and posttest by 5 experts through Item-Objective Congruence (IOC) according to the criteria as shown below:

1 = Sure that the question item is related to the objective

0 = Not sure that the question is related to the objective

-1 = Sure that the question is related to the objective

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures provides insights into the relevance and coherence of the rubric scoring criteria.

5. Design the conformity assessment form of the professional practical skills of electrical automation technology students.

**Data Collection**

1. Ask for permission of data collection.

2. Collect two groups of students' learning outcomes by using pretest before the experiment.

3. Carry out the experiment.

4. Collect two groups of students' learning outcomes by using post-test after the experiment.

**Data Analysis**

Descriptive statistics – Firstly, the overall test of the data, normality test, F test, T test, and then test the mean and combined standard deviation of the two groups of data.

The effect of a compare test can be measured by the effect size d value

**Expected Output Phase 3 (Pretest-Posttest)**

Results of implementing a modern practice teaching model in electrical automation technology - learning outcomes for students

# Chapter 4
# Data Analysis Results

In the study of "A Modern Practice Teaching Model for Electrical Automation Technologist Student", the researcher studied the documents concerning the following

Part 1: Analysis results serving objective 1. To study employers' practical skills requirements for electrical automation technology graduates.

Part 2: Analysis results serving objective 2. To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.

Part 3: Analysis results serving objective 3. To evaluate the modern practice teaching model of electrical automation technology major.

## Data Analysis Results

**Part 1: Analysis results serving objective 1. To study employers' practical skills requirements for electrical automation technology graduates.**

This section presents analysis results serving objective 1 using table and description in terms of MEAN, standard deviation, interpretation (Level of Attitude), and ranking of all factors in overview. After that, items of all factors are presented likewise.

**Table 4.1** Common data of the respondent in overall

| Name | Options | Frequency | Percentage |
|---|---|---|---|
| Number of employees | Less than 200 | 21 | 52.50 |
| | 200-500 | 10 | 25.00 |
| | 500-1000 | 7 | 17.50 |
| | More than 1000 | 2 | 5.00 |
| | Total | 40 | 100.00 |

**Table 4.1** (Continued)

| Name | Options | Frequency | Percentage |
|---|---|---|---|
| Industry | agricultural products processing | 12 | 30.00 |
| | Aluminum processing industry | 5 | 12.50 |
| | Chemical industry | 2 | 5.00 |
| | manufacturing | 9 | 22.50 |
| | Food industry | 3 | 7.50 |
| | Electronic industry | 9 | 22.50 |
| | Total | 40 | 100.00 |
| Region | Guangxi Province | 24 | 60.00 |
| | Pearl River Delta region | 7 | 17.50 |
| | Yangtze River Delta region | 3 | 7.50 |
| | Other regions | 6 | 15.00 |
| | Total | 40 | 100.0 |

According to Table 4.1, we can find that there are 40 companies participating in the survey, of which 24 companies from Guangxi Province account for 60% of the total. There are 7 and 3 enterprises from the Pearl River Delta and Yangtze River Delta, accounting for 17.5% and 7.5% respectively. There are 6 enterprises from other regions, accounting for 15%. This is in line with the actual employment situation of graduates majoring in electrical automation at Guangxi Vocational and Technical College. The majority of graduates from this school are employed within Guangxi Province, which is actually adjacent to the Pearl River Delta region of Guangxi Province. Meanwhile, through analyzing the industries to which enterprises belong, researchers have found that the three industries with the highest concentration of student employment are agricultural product processing, manufacturing, and electronics. In line with the actual situation, the main industries in Guangxi Province are agricultural product processing, followed by manufacturing and electronics. The main industries in the Pearl River Delta region are also manufacturing and electronics. From the perspective of the number of enterprises, 21 out of the surveyed enterprises have a scale of less than 200 people, accounting for 52.5%. However, as the scale increases, the number of enterprises gradually decreases, which is also in line with the actual situation.

Then analyze the reliability and validity of the questionnaire survey results on 36 ability needs of students majoring in electrical automation.

**Table 4.2** Reliability analysis results

| Capability requirements | CITC | Items deleted α | Cronbach α |
|---|---|---|---|
| Able to read and draw various electrical principles and circuit diagrams | 0.541 | 0.978 | 0.978 |
| Able to process parts | 0.700 | 0.977 | |
| Able to assemble and debug electronic circuits | 0.506 | 0.978 | |
| Able to recognize and draw mechanical structure diagrams | 0.575 | 0.978 | |
| Able to identify and detect commonly used electronic components | 0.526 | 0.978 | |
| Able to operate CNC machine tools | 0.766 | 0.977 | |
| Proficient in using commonly used instruments and meters | 0.523 | 0.978 | |
| Proficient in using commonly used electrical tools | 0.532 | 0.978 | |
| Able to design and analyze low-voltage electrical circuits | 0.448 | 0.978 | |
| Able to install and debug low-voltage electrical circuits | 0.626 | 0.978 | |
| Able to design C language programs | 0.761 | 0.977 | |
| Able to program microcontrollers | 0.888 | 0.977 | |
| Able to write PLC programs | 0.807 | 0.977 | |

**Table 4.2** (Continued)

| Capability requirements | CITC | Items deleted **α** | Cronbach **α** |
|---|---|---|---|
| Selection and driving capability of three-phase asynchronous motors | 0.811 | 0.977 | |
| Selection and driving ability of stepper motors | 0.785 | 0.977 | |
| Able to select and debug servo motors | 0.790 | 0.977 | |
| Can maintain the power supply and distribution system of the factory building | 0.807 | 0.977 | |
| Able to install and adjust automated production lines | 0.835 | 0.977 | |
| Can maintain industrial robots | 0.853 | 0.977 | |
| Able to simulate robot workstations | 0.867 | 0.977 | |
| Able to install and debug PLC control systems | 0.489 | 0.978 | |
| Able to troubleshoot PLC control system faults | 0.424 | 0.978 | |
| Proficient in operating equipment | 0.830 | 0.977 | |
| Able to manage equipment | 0.925 | 0.977 | |
| Able to design 3D drawings | 0.800 | 0.977 | |
| Able to operate industrial robots | 0.867 | 0.977 | |
| Able to use office software | 0.887 | 0.977 | |
| Able to operate CNC lathes | 0.794 | 0.977 | |
| Able to debug industrial networks | 0.835 | 0.977 | |
| Able to apply machine vision | 0.828 | 0.977 | |
| Able to install and debug pneumatic components | 0.807 | 0.977 | |
| Able to install and debug hydraulic components | 0.817 | 0.977 | |
| Able to perform 3D reverse design | 0.820 | 0.977 | |
| Proficient in using English | 0.751 | 0.977 | |
| Able to organize technical data according to specifications | 0.782 | 0.977 | |
| Able to learn new technologies | 0.826 | 0.977 | |

From the above table, it can be seen that the reliability coefficient value is 0.978, which is greater than 0.9, indicating that the reliability quality of the research data is very high. Regarding the CITC value, the CITC values of the analysis items are all greater than 0.4, indicating a good correlation between the analysis items and a good level of reliability. Therefore, the reliability coefficient value of the research data is higher than 0.9, which comprehensively indicates that the data reliability quality is high and can be used for further analysis.

**Table 4.3** Validity analysis results

| Capability requirements | Factor loading coefficient | | | | Commonality |
|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | |
| Able to read and draw various electrical principles and circuit diagrams | 0.183 | 0.900 | 0.139 | -0.067 | 0.867 |
| Able to process parts | 0.625 | 0.035 | 0.402 | 0.225 | 0.604 |
| Able to assemble and debug electronic circuits | 0.194 | 0.567 | 0.075 | 0.687 | 0.836 |
| Able to recognize and draw mechanical structure diagrams | 0.239 | 0.749 | 0.036 | 0.508 | 0.878 |
| Able to identify and detect commonly used electronic components | 0.133 | 0.891 | 0.104 | 0.176 | 0.854 |
| Able to operate CNC machine tools | 0.719 | 0.035 | 0.425 | 0.099 | 0.709 |
| Proficient in using commonly used instruments and meters | 0.167 | 0.781 | 0.227 | -0.040 | 0.690 |
| Proficient in using commonly used electrical tools | 0.141 | 0.909 | 0.156 | 0.008 | 0.871 |
| Able to design and analyze low-voltage electrical | 0.001 | 0.904 | 0.199 | 0.080 | 0.864 |

**Table 4.3** (Continued)

| Capability requirements | Factor loading coefficient | | | | Commonality |
|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | |
| Able to install and debug low-voltage electrical circuits | 0.319 | 0.837 | 0.060 | 0.170 | 0.834 |
| Able to design C language programs | 0.430 | 0.284 | 0.674 | 0.137 | 0.738 |
| Able to program microcontrollers | 0.614 | 0.267 | 0.620 | 0.188 | 0.869 |
| Able to write PLC programs | 0.506 | 0.308 | 0.652 | 0.050 | 0.779 |
| Selection and driving capability of three-phase asynchronous motors | 0.468 | 0.482 | 0.620 | -0.081 | 0.842 |
| Selection and driving ability of stepper motors | 0.478 | 0.407 | 0.640 | -0.161 | 0.830 |
| Able to select and debug servo motors | 0.424 | 0.517 | 0.528 | 0.141 | 0.747 |
| Can maintain the power supply and distribution system of the factory building | 0.714 | 0.247 | 0.181 | 0.486 | 0.839 |
| Able to install and adjust automated production lines | 0.561 | 0.195 | 0.565 | 0.458 | 0.882 |
| Can maintain industrial robots | 0.819 | 0.101 | 0.330 | 0.224 | 0.841 |
| Able to simulate robot workstations | 0.827 | 0.077 | 0.361 | 0.246 | 0.881 |
| Able to install and debug PLC control systems | 0.065 | 0.949 | 0.155 | 0.015 | 0.929 |
| Able to troubleshoot PLC control system faults | -0.012 | 0.913 | 0.140 | 0.110 | 0.866 |
| Proficient in operating equipment | 0.701 | 0.326 | 0.361 | 0.015 | 0.729 |
| Able to manage equipment | 0.841 | 0.295 | 0.331 | 0.059 | 0.907 |
| Able to design 3D drawings | 0.877 | 0.180 | 0.101 | 0.106 | 0.824 |

**Table 4.3** (Continued)

| Capability requirements | Factor loading coefficient | | | | Commonality |
|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | |
| Proficient in using English | 0.780 | 0.118 | 0.264 | -0.039 | 0.693 |
| Able to organize technical data according to specifications | 0.814 | 0.105 | 0.313 | -0.119 | 0.787 |
| Able to learn new technologies | 0.922 | 0.147 | 0.129 | 0.027 | 0.888 |
| Eigenvalue (before rotation) | 20.905 | 6.064 | 1.498 | 1.116 | - |
| Explanation rate of variance (before rotation) | 58.068% | 39.716% | 37.670% | 19.102% | - |
| Cumulative variance interpretation rate (before rotation) | 58.068% | 97.785% | 135.455% | 154.557% | - |
| Eigenvalue (after rotation) | 13.590 | 8.661 | 5.549 | 1.783 | - |
| Explanation rate of variance (after rotation) | 37.749% | 24.057% | 15.415% | 4.952% | - |
| Cumulative variance interpretation rate (after rotation) | 37.749% | 61.807% | 77.222% | 82.173% | - |
| KMO | 0.719 | | | | - |
| df | 630 | | | | - |
| p | 0.000 | | | | - |

Validity research is used to analyze whether the research item is reasonable and meaningful. Validity analysis is conducted using factor analysis, a data analysis method that comprehensively analyzes indicators such as KMO value, commonality, variance explanatory rate, and factor loading coefficient to verify the validity level of the data. The KMO value is used to determine the suitability of information extraction, the commonality value is used to exclude unreasonable research items, the variance explanatory rate value is used to indicate the level of information extraction, and the factor loading coefficient is used to measure the relationship between factors (dimensions) and item correspondence.

From the above table, it can be seen that the commonality values corresponding to all research items are higher than 0.4, indicating that the information of the research items can be effectively extracted. In addition, the KMO value is 0.719, which is greater than 0.7, indicating that the research data is suitable for extracting information (indicating good validity indirectly). In addition, the variance interpretation rates of the four factors were 37.749%, 24.057%, 15.415%, and 4.952%, respectively. After rotation, the cumulative variance interpretation rate was 82.173%>50%. This means that the information content of the research item can be effectively extracted.

**Table 4.4** The result of questionnaire form employers in overview

(N-40)

| Capability requirements | μ | δ | Interpretation | Ranking Within All Factors |
|---|---|---|---|---|
| Able to read and draw various electrical principles and circuit diagrams | 4.78 | 0.70 | High | 2 |
| Able to process parts | 3.43 | 1.50 | Low | 32 |
| Able to assemble and debug electronic circuits | 4.38 | 1.15 | Low | 10 |
| Able to recognize and draw mechanical structure diagrams | 4.55 | 0.85 | High | 9 |
| Able to identify and detect commonly used electronic components | 4.80 | 0.69 | High | 1 |
| Able to operate CNC machine tools | 3.28 | 1.68 | Low | 33 |
| Proficient in using commonly used instruments and meters | 4.70 | 0.76 | High | 3 |
| Proficient in using commonly used electrical tools | 4.70 | 0.82 | High | 4 |
| Able to design and analyze low-voltage electrical circuits | 4.70 | 0.85 | High | 5 |
| Able to install and debug low-voltage electrical circuits | 4.65 | 0.77 | High | 8 |
| Able to design C language programs | 3.98 | 1.07 | Low | 16 |
| Able to program microcontrollers | 3.90 | 1.03 | Low | 17 |
| Able to write PLC programs | 4.08 | 1.07 | Low | 11 |
| Selection and driving capability of three-phase asynchronous motors | 4.08 | 1.00 | Low | 12 |
| Selection and driving ability of stepper motors | 4.00 | 1.01 | Low | 15 |

**Table 4.4** (Continued)

| Capability requirements | μ | δ | Interpretation | Ranking Within All Factors |
|---|---|---|---|---|
| Able to select and debug servo motors | 4.05 | 1.01 | Low | 13 |
| Can maintain the power supply and distribution system of the factory building | 3.68 | 1.27 | Low | 24 |
| Able to install and adjust automated production lines | 3.75 | 1.28 | Low | 22 |
| Can maintain industrial robots | 3.55 | 1.45 | Low | 27 |
| Able to simulate robot workstations | 3.23 | 1.62 | Low | 36 |
| Able to install and debug PLC control systems | 4.70 | 0.82 | High | 6 |
| Able to troubleshoot PLC control system faults | 4.68 | 0.86 | High | 7 |
| Proficient in operating equipment | 4.05 | 1.11 | Low | 14 |
| Able to manage equipment | 3.88 | 1.07 | Low | 18 |
| Able to design 3D drawings | 3.58 | 1.32 | Low | 25 |
| Able to operate industrial robots | 3.58 | 1.34 | Low | 26 |
| Able to use office software | 3.78 | 1.23 | Low | 21 |
| Able to operate CNC lathes | 3.28 | 1.52 | Low | 34 |
| Able to debug industrial networks | 3.45 | 1.47 | Low | 31 |
| Able to apply machine vision | 3.50 | 1.43 | Low | 29 |
| Able to install and debug pneumatic components | 3.80 | 1.26 | Low | 19 |
| Able to install and debug hydraulic components | 3.80 | 1.24 | Low | 20 |
| Able to perform 3D reverse design | 3.25 | 1.56 | Low | 35 |
| Proficient in using English | 3.50 | 1.26 | Low | 30 |
| Able to organize technical data according to specifications | 3.53 | 1.38 | Low | 28 |
| Able to learn new technologies | 3.73 | 1.24 | Low | 23 |
| Total Average | 3.95 | 1.16 | — | |

The μ value of several items is also between 4.0-4.38. They are: Able to assemble and debug electronic circuits, Able to write PLC programs, Selection and driving capability of three-phase asynchronous motors, Able to select and debug servo motors, Proficient in operating equipment, Selection and driving ability of stepper motors. But the σ value of these items is between 1.01-1.55. It shows that different enterprises are not universal about the consistency of these needs, so these contents are not the most important focus.

To further prove the above statement, we have μ High value but σ Perform regression analysis on Able to assemble and debug electronic circuits with abnormal values.

**Table 4.5** Regression analysis of Able to assemble and debug electronic circuits

(N-40)

| Project | Regression Coefficients | t | p | VIF |
|---|---|---|---|---|
| Constant | 5.01 | 9.08 | 0.000** | - |
| Number of companies | -0.18 | -0.82 | 0.420 | 1.28 |
| The industry of the company | -0.14 | -1.32 | 0.195 | 1.28 |
| The company's area | 0.08 | 0.43 | 0.670 | 1.35 |
| Sample amount | 40 | | | |
| $R^2$ | 0.103 | | | |
| Adjustment $R^2$ | 0.028 | | | |
| F | F(3,36)=1.381,p=0.264 | | | |
| * p<0.05 ** p<0.01 | | | | |

As can be seen from the table above, the P value of the F test is 0.264, indicating that the overall fitting of the regression model is not significant, that is, at least one independent variable in the model does not have a significant linear relationship between the variables.

The regression coefficient of the "number of corporate employees" of the independent variable is -0.18, the T value is -0.82, and the P value is 0.420, indicating that the effect of the independent variable on the variable is not significant.

The regression coefficient of the independent variable "industry" is -0.14, T value is -1.32, and a P value is 0.195, indicating that the effect of the independent variable on the dependent variable is not significant.

The regression coefficient of the "area where the enterprise is located" is 0.08, the T value is 0.43, and the P value is 0.670, which also indicates that the effect of the independent variable on the cause is not significant.

Therefore, the results of the regression analysis show that the effects of the three independent variables on the variable are not significant. Therefore, this part of the ability requirements are not used as a reference basis for the design of the teaching model of subsequent modern apprentices.

In summary, through the first stage of research, it has been concluded that the demand for practical abilities of electrical automation technology students in enterprises is as follows:

Able to identify and detect commonly used electronic components

Able to read and draw various electrical principles and circuit diagrams

Proficient in using commonly used instruments and meters

Proficient in using commonly used electrical tools

Able to design and analyze low-voltage electrical circuits

Able to install and debug PLC control systems

Able to troubleshoot PLC control system faults

Able to install and debug low-voltage electrical circuits

Able to recognize and draw mechanical structure diagrams

**Part 2: Analysis results serving objective 2. To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.**

Researchers analyze the needs of 9 professional practical ability of electrical automation technology. The results are shown in Figure 4-1.

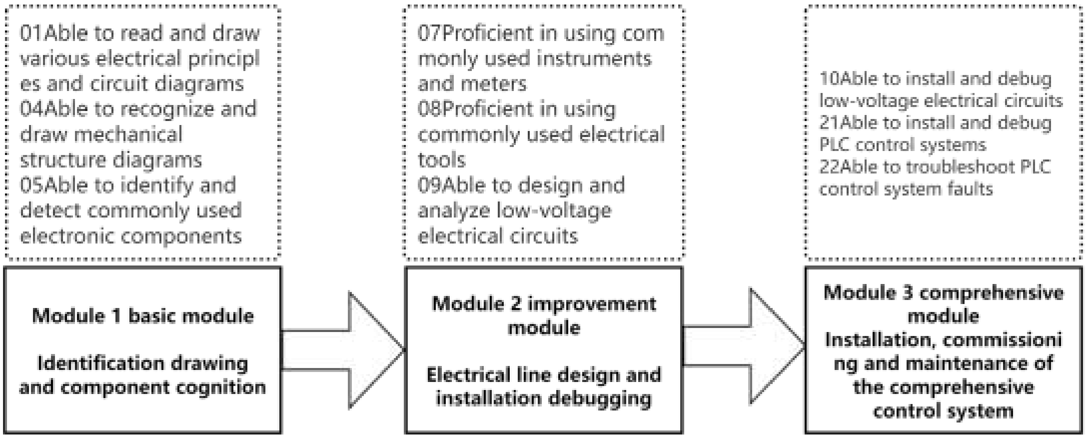


**Figure 4.1** Classification diagram of students' practical ability of electrical automation technology

As can be seen from the figure above, the researchers divide the 9 capabilities of enterprises into 3 modules, namely: basic modules -recognition drawing drawing and component cognition, improving module -electrical line design and installation debugging, comprehensive module - - Installation, commissioning and maintenance of the comprehensive control system. Training students through basic modules can master the readings and drawings of parts diagrams, diagrams and drawings of circuit diagrams, and the understanding and measurement of basic electronic components. By improving the module's training students can master the use of electrical tools, the operations of basic electrical equipment and instruments, and the design and analysis of the design and analysis of low -voltage electrical lines. Through training students of comprehensive modules can master comprehensive skills such as installation and debugging of common low -voltage electrical lines, installation, commissioning and maintenance of the PLC control system. From the perspective of students' learning and cognition, these modules are a progressive relationship. After students learn and master the ability of the previous module, they can enter the study of subsequent module courses.

Focusing on the 9 capabilities of the above 3 modules, the researchers and school teachers, engineering practice experts, and teaching managers have designed the apprenticeship teaching model. The core framework is shown in the table 4.6.

According to Table 4.6, each professional practical ability can be further refined into knowledge points. Use this as a basis to determine specific courses.

**01Able to read and draw various Electrical principles and circuit diagrams:**

Component symbol recognition, schematic analysis method, typical electrical schematic analysis, three-phase asynchronous motor start stop circuit, three-phase asynchronous motor forward and reverse circuit, three-phase asynchronous motor braking circuit, three-phase asynchronous motor speed control circuit.

**04Able to recognize and draw mechanical structure diagrams:** Basic methods of drawing, basic principles and characteristics of projection, projection and surface intersection lines of basic bodies, combination and axonometric drawings, expression methods of machine parts, standard and commonly used parts, part drawings and assembly drawings

**05Able to identify and detect commonly Used electronic components:** Symbols for electronic components, identification and detection of color ring resistors, identification and detection of diodes, identification and detection of transistors, identification and detection of capacitors, identification and detection of inductors, identification and detection of relays

**07Proficient in using commonly used instruments and meters:** Correct use of measuring instruments such as electric pens, multimeters, megohmmeters, clamp ammeters, oscilloscopes, signal generators, logic analyzers, etc

**08Proficient in using commonly used electrical tools:** The correct use of tools such as soldering iron, solder absorber, tweezers, electric pen, electrician's knife, adjustable wrench and hammer, screwdriver, pliers, wire stripping pliers, diagonal pliers, scissors, pointed nose pliers, pliers, tape measure, internal and external hex wrench, etc

**09Able to design and analyze low-voltage electrical circuits:** Design and analysis of DC stabilized power supply, DC circuit, basic amplification circuit, power amplification circuit, three-phase asynchronous motor and other circuits

**Table 4.6** Detailed Table of Modern Ppractice Teaching Model Design

| Professional practice ability | Classification Description | Specific knowledge | Course |
|---|---|---|---|
| 01Able to read and draw various Electrical principles and circuit diagrams | Module 1 basic module Identification drawing and component cognition | Component symbol recognition, schematic analysis method, typical electrical schematic analysis, three-phase asynchronous motor start stop circuit, three-phase asynchronous motor forward and reverse circuit, three-phase asynchronous motor braking circuit, three-phase asynchronous motor speed control circuit. | |
| 04Able to recognize and draw mechanical structure diagrams | | Basic methods of drawing, basic principles and characteristics of projection, projection and surface intersection lines of basic bodies, combination and axonometric drawings, expression methods of machine parts, standard and commonly used parts, part drawings and assembly drawings | |
| 05Able to identify and detect commonly Used electronic components | | Symbols for electronic components, identification and detection of color ring resistors, identification and detection of diodes, identification and detection of transistors, identification and detection of capacitors, identification and detection of inductors, identification and detection of relays | |

**Table 4.6** (Continued)

| Professional practice ability | Classification Description | Specific knowledge | Course |
|---|---|---|---|
| 07Proficient in using com monly used instruments and meters | Module 2 improvement m odule Electrical line design and Installation debugging | Correct use of measuring instruments such as electric pens, multimeters, megohmmeters, clamp ammeters, oscilloscopes, signal generators, logic analyzers, etc | 4. Electrical and Electronic Technology Training<br>5. Installation and commissioning of non-standard electromechanical products<br>6. Motor Drive Technology |
| 08Proficient in using com monly used electrical too ls | | The correct use of tools such as soldering iron, solder absorber, tweezers, electric pen, electrician's knife, adjustable wrench and hammer, screwdriver, pliers, wire stripping pliers, diagonal pliers, scissors, pointed nose pliers, pliers, tape measure, internal and external hex wrench, etc | |
| 09Able to design and anal yze low-voltage electrical circuits | | Design and analysis of DC stabilized power supply, DC circuit, basic amplification circuit, power amplification circuit, three-phase asynchronous motor and other circuits | |

**Table 4.6** (Continued)

| Professional practice ability | Classification Description | Specific knowledge | Course |
|---|---|---|---|
| 10Able to install and debug low-voltage electrical circuits | Module 3 comprehensive module | Installation and debugging of low-voltage distribution lines, lighting lines, ordinary machine tools and other circuits | 7. PLC Engineering Training<br>8. Maintenance of Intelligent Manufacturing Production Lines<br>9. Productive Training |
| 21Able to install and debug PLC control systems | Installation, commissioning and maintenance of the comprehensive control system | Understand the structural principles of PLC, be familiar with the installation and use of PLC, master the use of PLC programming components, master the PLC instruction system, be familiar with ladder diagram programming language and programming environment, master the preparation and use of program flowcharts, and master the software and hardware debugging of PLC control systems | |
| 22Able to troubleshoot PLC control system faults | | Sensor related knowledge, PLC communication knowledge, application of PLC extension modules, PLC anti-interference processing methods, frequency converter knowledge, servo knowledge | |

**10Able to install and debug low-voltage electrical circuits:** Installation and debugging of low-voltage distribution lines, lighting lines, ordinary machine tools and other circuits

**21Able to install and debug PLC control systems:** Understand the structural principles of PLC, be familiar with the installation and use of PLC, master the use of PLC programming components, master the PLC instruction system, be familiar with ladder diagram programming language and programming environment, master the preparation and use of program flowcharts, and master the software and hardware debugging of PLC control systems

**22Able to troubleshoot PLC control system faults:** Sensor related knowledge, PLC communication knowledge, application of PLC extension modules, PLC anti-interference processing methods, frequency converter knowledge, servo knowledge

Afterwards, based on the above analysis and combined with the production situation of the enterprise, the above knowledge points will be decomposed into 9 modern practice courses, forming a new curriculum framework. The course names are:

1. Pre job safety production training
2. Electrical Diagram Recognition and Circuit Maintenance
3. Mechanical Drawing and Sugar Making Equipment Management
4. Electrical and Electronic Technology Training
5. Installation and commissioning of non-standard electromechanical products
6. Motor Drive Technology
7. PLC Engineering Training
8. Maintenance of Intelligent Manufacturing Production Lines
9. Productive Training

After determining the courses offered by the modern practice system, we entered the stage of writing curriculum standards. Based on specific ability requirements, enterprise production situation, and school teaching process, we wrote the modern practice curriculum standards for the nine courses mentioned above. The curriculum standards include course positioning and objectives, content requirements, teaching organization and evaluation standards, etc., which explain the connotation of each content and provide an implementation basis for the modern practice system curriculum teaching of both schools and enterprises. At the same time, the course content was further refined according to the curriculum standards, and the teaching tasks for each course were determined.

In order to ensure the standardized implementation of modern practice teaching mode, an implementation plan has been formulated. This includes three aspects: teacher team building plan, curriculum resource construction plan, and practical training base construction plan.

The teaching team consists of two types of personnel: school teachers and enterprise engineers. The content of the teacher team building plan includes: firstly, clarifying the requirements for dual mentors, explaining the scale, qualifications, and abilities of school enterprise mentors. Generally, enterprise mentors come from excellent employees with outstanding frontline business abilities in cooperative enterprise management positions, professional positions, professional technical training positions, and professional frontline business abilities. They have more than 5 years of work experience, good language expression skills, basic teaching abilities, and relevant professional qualifications. The second is to clarify the member structure (number of school teachers, number of enterprise engineers), the responsibilities and roles of team members, training plans for team members, and assessment methods for the team.

The curriculum resource construction plan is mainly designed based on the characteristics of the modern learning system, such as dual teacher teaching and on-site production teaching. Construct different teaching resources according to the different venues of course teaching. For example: video, audio, network resources, document material resources, assessment resources, etc.

The construction plan for the training base includes both on campus and off campus training bases, and the on campus training base is already very complete. Therefore, this section mainly clarifies the requirements for the construction of off campus training bases. This plan specifies the relevant requirements for enterprises that are in line with the Electrical Automation Technology major to provide production workshops and other places as apprenticeship student training bases. Clarify the management system of the training base, training material management system, production and training safety system, etc.

This section presents analysis results serving objective 2 using table and description in terms of MEAN, standard deviation.

**Table 4.7** Overall situation

| Name | Options | Frequency | Percentage |
|---|---|---|---|
| Occupation | Enterprise Engineer | 5 | 20.83 |
| | Vocational school teachers | 6 | 25.00 |
| | Enterprise HR | 5 | 20.83 |
| | Vocational education experts | 4 | 16.67 |
| | Teaching management personnel in vocational schools | 4 | 16.67 |
| | Total | 24 | 100 |
| Professional title | Primary Title | 1 | 4.17 |
| | Middle Title | 8 | 33.33 |
| | Vice-senior Title | 10 | 41.67 |
| | Senior Title | 5 | 20.83 |
| | Total | 24 | 100 |
| Age | Below 30 | 2 | 8.33 |
| | 30-40 | 9 | 37.50 |
| | 40-50 | 9 | 37.50 |
| | Over 50 | 4 | 16.67 |
| | Total | 24 | 100 |

According to Table 4.7, the total number of sample participants in the questionnaire survey is 24. From a professional perspective, they come from 5 different fields, with a minimum of 4 and a maximum of 6 people, roughly equivalent in number. The collected data can comprehensively reflect the attitudes of individuals from different fields towards the apprenticeship teaching model. From the perspective of professional title types, there are 10 people with deputy senior professional titles and 5 people with senior professional titles, with a combined proportion of 62.5%. The attitude of personnel with senior professional titles is more persuasive. From the age structure of the respondents, there are 22 people over the age of 30, accounting for a total of 91.67%. The older the age, the richer the experience of the interviewee. Therefore, from the perspective of occupational characteristics, title structure, and age structure, the collected data has strong representativeness and can reflect the real situation.

Then analyze the reliability and validity of the appropriate questionnaire survey results of modern practice teaching models of electrical automation.

**Table 4.8** Reliability analysis results

| Option | CITC | Items deleted α | Cronbach α |
|---|---|---|---|
| Job analysis | 0.264 | 0.930 | 0.927 |
| Job ability requirements | 0.831 | 0.917 | |
| Analysis of typical work tasks | 0.504 | 0.926 | |
| Knowledge Point Organization | 0.624 | 0.923 | |
| Curriculum system construction | 0.683 | 0.922 | |
| Design of assessment methods | 0.662 | 0.923 | |
| Curriculum Standards for Pre job Safety Production Training | 0.582 | 0.924 | |
| Curriculum Standards for Factory Power Distribution and Maintenance | 0.774 | 0.919 | |
| Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | 0.741 | 0.923 | |
| Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | 0.437 | 0.927 | |
| Curriculum Standards for Installation and Maintenance of Vertical Warehouse | 0.329 | 0.928 | |
| Curriculum Standards for Installation and commissioning of non-standard electromechanical products | 0.742 | 0.920 | |
| Curriculum Standards for Motor Drive Technology | 0.823 | 0.918 | |
| Curriculum Standards for Industrial Networking and Data Collection | 0.818 | 0.918 | |
| Curriculum Standards for Productive Training | 0.730 | 0.922 | |
| Teacher Team Building Plan | 0.089 | 0.932 | |
| Curriculum resource construction plan | 0.894 | 0.920 | |
| Training Environment Construction Plan | 0.732 | 0.920 | |

From the above table, it can be seen that this analysis is based on 24 samples, and the questionnaire contains 18 items. Cronbach $\alpha$ The coefficient value is 0.927, which is greater than 0.9, indicating high reliability of the research data and the possibility of further research.

**Table 4.9** Validity analysis results

| Option | Factor loading coefficient Factor 1 | Factor 2 | Factor 3 | Factor 4 | Commonality |
|---|---|---|---|---|---|
| Job analysis | 0.88 | 0.28 | -0.14 | 0.03 | 0.865 |
| Job ability requirements | 0.48 | 0.51 | -0.30 | -0.15 | 0.604 |
| Analysis of typical work tasks | -0.23 | 0.67 | -0.06 | -0.33 | 0.618 |
| Knowledge Point Organization | -0.13 | 0.24 | 0.80 | -0.18 | 0.747 |
| Curriculum system construction | -0.18 | 0.15 | 0.25 | 0.82 | 0.788 |
| Design of assessment methods | 0.31 | 0.09 | -0.10 | 0.80 | 0.752 |
| Curriculum Standards for Pre job Safety Production Training | 0.63 | 0.30 | 0.03 | 0.36 | 0.608 |
| Curriculum Standards for Factory Power Distribution and Maintenance | 0.03 | 0.29 | 0.83 | -0.13 | 0.789 |
| Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | 0.275 | 0.676 | 0.576 | 0.104 | 0.875 |
| Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | 0.42 | 0.69 | 0.10 | -0.05 | 0.664 |
| Curriculum Standards for Installation and Maintenance of Vertical Warehouse | -0.45 | 0.72 | -0.42 | 0.04 | 0.904 |

**Table 4.9** (Continued)

| Option | Factor loading coefficient | | | | Commonality |
|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | |
| Curriculum Standards for Installation and commissioning of non-standard electromechanical products | -0.44 | 0.42 | -0.34 | 0.14 | 0.503 |
| Curriculum Standards for Motor Drive Technology | 0.88 | 0.28 | -0.14 | 0.03 | 0.865 |
| Curriculum Standards for Industrial Networking and Data Collection | -0.08 | -0.03 | 0.60 | 0.19 | 0.406 |
| Curriculum Standards for Productive Training | -0.09 | 0.47 | -0.19 | 0.42 | 0.448 |
| Teacher Team Building Plan | -0.01 | -0.11 | -0.08 | 0.59 | 0.362 |
| Curriculum resource construction plan | 0.751 | 0.440 | 0.396 | 0.076 | 0.921 |
| Training Environment Construction Plan | 0.71 | 0.20 | 0.01 | -0.04 | 0.538 |
| Eigenvalue (before rotation) | 3.85 | 2.42 | 2.18 | 2.01 | - |
| Explanation rate of variance (before rotation) | 21.39% | 13.46% | 12.13% | 11.15% | - |
| Cumulative variance interpretation rate (before rotation) | 21.39% | 34.85% | 46.98% | 58.13% | - |
| Eigenvalue (after rotation) | 3.45 | 2.57 | 2.25 | 2.20 | - |
| Explanation rate of variance (after rotation) | 19.18% | 14.25% | 12.49% | 12.21% | - |
| Cumulative variance interpretation rate (after rotation) | 19.18% | 33.43% | 45.92% | 58.13% | - |
| KMO | 0.736 | | | | - |

From the above table, it can be seen that a total of four factors were extracted, and the cumulative variance explanatory rate of these four factors reached 58.13%, indicating that these four factors can explain most of the questionnaire data variability. The explained variance after rotation showed that the first factor explained 19.18% of the variance, while the fourth factor explained 12.21% of the variance, indicating that these factors have strong explanatory power for the questionnaire data. The KMO value is 0.736, indicating good validity and potential for further research.

**Table 4.10** Overview of the Results of the Apprenticeship Teaching Model Suitability Questionnaire

(N-24)

| Option | μ | δ |
|---|---|---|
| Job analysis | 4.875 | 0.448 |
| Job ability requirements | 4.365 | 0.637 |
| Analysis of typical work tasks | 4.708 | 0.550 |
| Knowledge Point Organization | 4.708 | 0.550 |
| Curriculum system construction | 4.625 | 0.770 |
| Design of assessment methods | 4.625 | 0.711 |
| Curriculum Standards for Pre job Safety Production Training | 4.792 | 0.509 |
| Curriculum Standards for Factory Power Distribution and Maintenance | 4.708 | 0.550 |
| Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | 4.917 | 0.282 |
| Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | 4.750 | 0.532 |
| Curriculum Standards for Installation and Maintenance of Vertical Warehouse | 4.833 | 0.381 |
| Curriculum Standards for Installation and commissioning of non-standard electromechanical products | 4.750 | 0.676 |
| Curriculum Standards for Motor Drive Technology | 4.792 | 0.588 |
| Curriculum Standards for Industrial Networking and Data Collection | 4.708 | 0.624 |
| Curriculum Standards for Productive Training | 4.592 | 0.415 |
| Teacher Team Building Plan | 4.875 | 0.338 |
| Curriculum resource construction plan | 4.875 | 0.338 |
| Training Environment Construction Plan | 4.708 | 0.624 |

From the above table, it can be seen that the average score of the 18 items to be evaluated is between 4.365 and 4.917, and the standard deviation is between 0.282 and 0.770. After evaluation by 24 experts, each project design of the modern practice teaching model is relatively reasonable.

**Table 4.11** Frequency analysis results

(N-24)

| Name | option | Frequency | Percentage (%) | Accumulated percentage (%) |
|---|---|---|---|---|
| Job analysis | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 10 | 41.67 | 45.83 |
| | EXCELLENT | 13 | 54.17 | 100.00 |
| Job ability requirements | AVERAGE | 4 | 16.67 | 16.67 |
| | GOOD | 11 | 45.83 | 62.50 |
| | EXCELLENT | 9 | 37.50 | 100.00 |
| Analysis of typical work tasks | AVERAGE | 8 | 33.33 | 33.33 |
| | GOOD | 6 | 25.00 | 58.33 |
| | EXCELLENT | 10 | 41.67 | 100.00 |
| Knowledge Point Organization | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 10 | 41.67 | 45.83 |
| | EXCELLENT | 13 | 54.17 | 100.00 |
| Curriculum system construction | AVERAGE | 3 | 12.50 | 12.50 |
| | GOOD | 15 | 62.50 | 75.00 |
| | EXCELLENT | 6 | 25.00 | 100.00 |
| Design of assessment methods | AVERAGE | 5 | 20.83 | 20.83 |
| | GOOD | 11 | 45.83 | 66.67 |
| | EXCELLENT | 8 | 33.33 | 100.00 |

**Table 4.11** (Continued)

(N-24)

| Name | option | Frequency | Percentage (%) | Accumulated percentage (%) |
|---|---|---|---|---|
| Curriculum Standards for Pre job Safety Production Training | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 5 | 20.83 | 25.00 |
| | EXCELLENT | 18 | 75.00 | 100.00 |
| Curriculum Standards for Factory Power Distribution and Maintenance | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 7 | 29.17 | 33.33 |
| | EXCELLENT | 16 | 66.67 | 100.00 |
| Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | GOOD | 6 | 25.00 | 25.00 |
| | EXCELLENT | 18 | 75.00 | 100.00 |
| Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | AVERAGE | 3 | 12.50 | 12.50 |
| | GOOD | 3 | 12.50 | 25.00 |
| | EXCELLENT | 18 | 75.00 | 100.00 |
| Curriculum Standards for Installation and Maintenance of Vertical Warehouse | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 8 | 33.33 | 37.50 |
| | EXCELLENT | 15 | 62.50 | 100.00 |

**Table 4.11** (Continued)

(N-24)

| Name | option | Frequency | Percentage (%) | Accumulated percentage (%) |
|---|---|---|---|---|
| Curriculum Standards for Installation and commissioning of non-standard electromechanical products | AVERAGE | 2 | 8.33 | 8.33 |
| | GOOD | 2 | 8.33 | 16.67 |
| | EXCELLENT | 20 | 83.33 | 100.00 |
| Curriculum Standards for Motor Drive Technology | AVERAGE | 1 | 4.17 | 4.17 |
| | GOOD | 5 | 20.83 | 25.00 |
| | EXCELLENT | 18 | 75.00 | 100.00 |
| Curriculum Standards for Industrial Networking and Data Collection | AVERAGE | 3 | 12.50 | 12.50 |
| | GOOD | 4 | 16.67 | 29.17 |
| | EXCELLENT | 17 | 70.83 | 100.00 |
| Curriculum Standards for Productive Training | AVERAGE | 4 | 16.67 | 16.67 |
| | GOOD | 9 | 37.50 | 54.17 |
| | EXCELLENT | 11 | 45.83 | 100.00 |
| Teacher Team Building Plan | PASS | 1 | 4.17 | 4.17 |
| | AVERAGE | 3 | 12.50 | 16.67 |
| | GOOD | 13 | 54.17 | 70.83 |
| | EXCELLENT | 7 | 29.17 | 100.00 |
| Curriculum resource construction plan | AVERAGE | 6 | 25.00 | 25.00 |
| | GOOD | 8 | 33.33 | 58.33 |
| | EXCELLENT | 10 | 41.67 | 100.00 |

**Table 4.11** (Continued)

(N-24)

| Name | option | Frequency | Percentage (%) | Accumulated percentage (%) |
|---|---|---|---|---|
| Training Environment Construction Plan | PASS | 3 | 12.50 | 12.50 |
| | AVERAGE | 7 | 29.17 | 41.67 |
| | GOOD | 6 | 25.00 | 66.67 |
| | EXCELLENT | 8 | 33.33 | 100.00 |
| Total | | 24 | 100.0 | 100.0 |

From the above table, it can be seen that from the job position analysis, there are relatively more "excellent" in the sample, accounting for 54.17%. 41.67% of the samples are considered good. From the distribution of job competency requirements, the majority of the samples are "good", with a total of 11.0, accounting for 45.83%. In addition, the proportion of excellent samples is 37.50%. The proportion of "excellent" is 41.67%. The proportion of moderate samples is 33.33%. More than 50% of the samples selected in the knowledge point sorting are "excellent". The proportion of good samples is 41.67%. 62.50% of the samples are considered "good". The proportion of "good" is 45.83%. 33.33% of the samples are excellent. For the 7. "Pre job Safety Production Training" course standard, the highest proportion of "excellent" is 75.00%. 66.67% of the samples are considered excellent. The proportion of "excellent" is 75.00%. 75.00% of the samples are considered excellent. The proportion of "excellent" is 62.50%. The proportion of good samples is 33.33%. More than 80% of the samples in the "Motor Drive Technology" course standard are selected as "excellent". 75.00% of the samples will choose "excellent". According to the 14. "Intelligent Manufacturing Production Line Maintenance" course standard, over 70% of the samples are considered "excellent". According to the 15. Productive Training course standard, over 40% of the samples are considered "excellent". 37.50% of the samples are still good. The proportion of selecting "good" in the sample is 54.17%. The proportion of selecting "excellent" in the sample is 41.67%. The proportion of good samples is 33.33%. From the distribution of training venue construction plans, the majority of the samples are "excellent", with a total of 8.0, accounting for 33.33%.

In summary, the modern practice teaching model for electrical automation technology majors has been recognized by experts from different fields, and all projects have passed expert evaluations with high scores. The modern practice teaching model for students majoring in electrical automation technology is feasible and can enter the next stage of research.

**Part 3: Analysis results serving objective 3. To evaluate the modern practice teaching model of electrical automation technology major.**

The third stage of this study can be divided into the following three steps:

The first step: pre-test. In September 2023, the experimental group and the control group were tested for their practical ability in electrical automation technology. The groups were slightly adjusted according to the test results to ensure that there was no significant difference in the academic level between the experimental group and the control group;

The second step: teaching implementation. From September 2023 to June 2024, the experimental group adopted the modern practice teaching model developed in the previous research stage for teaching, and the control group adopted the ordinary teaching model for teaching.

The third step: post-test. At the end of June 2024, after training in two different teaching models, the practical ability of the experimental group and the control group students was evaluated using practical skills assessment questions to understand the improvement of their practical ability after learning.

The students of Class 1 of electrical automation technology major adopt the traditional teaching model, and the course opening plan for each semester is as Table 4.12:

The 21st grade electrical automation technology major class 2 adopts the modern practice teaching mode. The course schedule for each semester is as Table 4.13:

**Table 4.12** 2021 Electrical Automation Technology Major Course Setting and Teaching Schedule (Traditional)

| Course category | | No | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | | 1 | College Chinese | 3 | 48 | 42 | 6 | 48 | | | | | |
| | | 2 | Ancient Chinese History | 4 | 64 | 54 | 10 | 64 | | | | | |
| | | 3 | Modern Chinese History | 1 | 48 | 48 | 0 | 48 | | | | | |
| | | 4 | Career Planning and Entrepreneurship Guidance | 1 | 44 | 0 | 44 | 44 | | | | | |
| | | 5 | Military Courses and Admission Education for College Students | 4 | 148 | 36 | 112 | 14<br>8 | | | | | |
| Public basic courses | Basic quality courses | 6 | Psychological Health Education for College Students | 2 | 32 | 24 | 8 | 32 | | | | | |
| | | 7 | Physical Education | 6 | 120 | 0 | 120 | 30 | 30 | 30 | 30 | | |
| | | 8 | Labor Education | 1 | 24 | 12 | 12 | | 24 | | | | |
| | | 9 | Foundation of Entrepreneurship for College Students | 2 | 40 | 0 | 40 | | | | | | |
| | | 10 | College English | 2 | 32 | 32 | 0 | | 32 | | | | |
| | | 11 | Professional English 1 | 2 | 32 | 32 | 0 | 32 | | | | | |
| | | 12 | Professional English 2 | 2 | 32 | 32 | 0 | | 32 | | | | |

**Table 4.12** (Continued)

| Course category | | No | Course Title | Semester | Hours | theory | practice | Semester/Hours 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Professional Learning Area Courses | Professional basic courses | 1 | Applied mathematics for electrical engineering | 2 | 36 | 36 | | | 36 | | | | |
| | | 2 | Computer and network application technology | 3 | 50 | 40 | 10 | | 50 | | | | |
| | | 3 | Electrical engineering technology | 2.5 | 48 | 24 | 24 | | 48 | | | | |
| | | 4 | Mechanical drawing | 3 | 60 | 40 | 20 | | 60 | | | | |
| | | 5 | Parts clamp processing | 1.5 | 28 | 8 | 20 | | 28 | | | | |
| | | 6 | AutoCAD | 2 | 40 | 20 | 20 | | 40 | | | | |
| | Module 1 Course | 7 | Electronic technology | 3 | 54 | 44 | 10 | | | 54 | | | |
| | | 8 | Application of power supply and distribution technology in factories | 3 | 54 | 30 | 24 | | | 54 | | | |
| | | 9 | Equipment management and preventive maintenance | 2 | 36 | 26 | 10 | | | 36 | | | |
| | | 10 | Electrical engineering drawing | 2 | 36 | 26 | 10 | | | 36 | | | |
| | | 11 | Hydraulic and pneumatic technology | 2.5 | 48 | 20 | 28 | | | 44 | | | |

**Table 4.12** (Continued)

| Course category | No | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| Module 2 Course | 12 | Electrical circuit analysis and installation and debugging | 4 | 72 | 52 | 20 | | | 72 | | | |
| | 13 | Automated production line installation and debugging | 4 | 72 | 62 | 10 | | | 72 | | | |
| Module 3 Course | 14 | Microcontroller application technology | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 15 | C language programming basics | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 16 | Detection and process control technology | 2 | 44 | 30 | 14 | | | | 44 | | |
| | 17 | Configuration and touch screen control technology | 2 | 36 | 20 | 16 | | | | 36 | | |
| | 18 | PLC control system installation and programming | 4 | 72 | 52 | 20 | | | | 72 | | |
| | 19 | Machine tool electrical circuit maintenance | 2.5 | 44 | 30 | 14 | | | | 44 | | |

**Table 4.12** (Continued)

| Course category | | No | Course Title | Semester | Hours | theory | practice | Semester/Hours 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 20 | Industrial robot technology application | 4 | 72 | 62 | 10 | | | | 72 | | |
| | Professional practice module | 21 | On-the-job internship | 24 | 576 | | 576 | | | | | | 576 |
| | | 22 | Graduation project (thesis) | 6 | 120 | | 120 | | | | | 120 | |
| Professional Elective | Elective modules | 1 | Motion control technology | 4 | 72 | 62 | 10 | | | | | 72 | |
| | | 2 | Industrial robot application and programming | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | 3 | Machine vision technology | 2 | 36 | 26 | 10 | | | | | 36 | |
| | | 4 | Industrial network technology | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | 5 | DCS system installation, commissioning and operation and maintenance | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | | Total | 130 | 2640 | 1212 | 1428 | 446 | 420 | 398 | 406 | 390 | 576 |

**Table 4.13** 2021 Electrical Automation Technology Major Course Setting and Teaching Schedule (Modern Practice System)

| Course category | | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| Public basic courses | Basic quality courses | 1 | College Chinese | 3 | 48 | 42 | 6 | 48 | | | | | |
| | | 2 | Ancient Chinese History | 4 | 64 | 54 | 10 | 64 | | | | | |
| | | 3 | Modern Chinese History | 1 | 48 | 48 | 0 | 48 | | | | | |
| | | 4 | Career Planning and Entrepreneurship Guidance | 1 | 44 | 0 | 44 | 44 | | | | | |
| | | 5 | Military Courses and Entrance Education for College Students | 4 | 148 | 36 | 112 | 148 | | | | | |
| | | 6 | Psychological Health Education for College Students | 2 | 32 | 24 | 8 | 32 | | | | | |
| | | 7 | Physical Education | 6 | 120 | 0 | 120 | 30 | 30 | 30 | 30 | | |
| | | 8 | Labor Education | 1 | 24 | 12 | 12 | | 24 | | | | |
| | | 9 | Foundation of Entrepreneurship for College Students | 2 | 40 | 0 | 40 | | 40 | | | | |
| | | 10 | College English | 2 | 32 | 32 | 0 | | 32 | | | | |

**Table 4.13** (Continued)

| Course category | | No | Course Title | Semester | | | | Semester/Hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | | 11 | Professional English 1 | 2 | 32 | 32 | 0 | 32 | | | | | |
| | | 12 | Professional English 2 | 2 | 32 | 32 | 0 | | 32 | | | | |
| | | 1 | Applied Mathematics for Electrical Majors | 2 | 36 | 36 | | | 36 | | | | |
| | | 2 | Computer and Network Application Technology | 3 | 50 | 40 | 10 | | 50 | | | | |
| Professional Learning Area Courses | Professional basic courses | 3 | Electrical Engineering Technology | 2.5 | 48 | 24 | 24 | | 48 | | | | |
| | | 4 | Mechanical Drawing | 3 | 60 | 40 | 20 | | 60 | | | | |
| | | 5 | Parts Claw Processing | 1.5 | 28 | 8 | 20 | | 28 | | | | |
| | | 6 | AutoCAD | 2 | 40 | 20 | 20 | | 40 | | | | |
| | | 7 | Electronic Technology | 3 | 54 | 44 | 10 | | | 54 | | | |
| | Module 1 Course | 8 | Application of Factory Power Supply and Distribution Technology | 3 | 54 | 30 | 24 | | | 54 | | | |

**Table 4.13** (Continued)

| Course category | No | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | 9 | Equipment Management and Preventive Maintenance | 2 | 36 | 26 | 10 | | | 36 | | | |
| | 10 | Electrical Engineering Drawing | 2 | 36 | 26 | 10 | | | 36 | | | |
| | 11 | Hydraulic and Pneumatic Technology | 2.5 | 48 | 20 | 28 | | | 44 | | | |
| | 12 | Electrical Circuit Analysis and Installation and Debugging | 4 | 72 | 52 | 20 | | | 72 | | | |
| Module 2 Course | 13 | Automated Production Line Installation and Debugging | 4 | 72 | 62 | 10 | | | 72 | | | |
| | 14 | Microcontroller Application Technology | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 15 | C Language Programming Basics | 3 | 54 | 44 | 10 | | | | 54 | | |

**Table 4.13** (Continued)

| Course category | | No | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | Module 3 Course | 16 | Detection and Process Control Technology | 2 | 44 | 30 | 14 | | | | 44 | | |
| | | 17 | Configuration and Touch Screen Control Technology | 2 | 36 | 20 | 16 | | | | 36 | | |
| | | 18 | PLC Control System Installation and Programming | 4 | 72 | 52 | 20 | | | | 72 | | |
| | | 19 | Machine Tool Electrical Circuit Maintenance | 2.5 | 44 | 30 | 14 | | | | 44 | | |
| | | 20 | Industrial Robot Technology Application | 4 | 72 | 62 | 10 | | | | 72 | | |
| Practical skills improvement area | Modern practice courses | 1 | Pre-job Safety Production Training | 2 | 36 | 26 | 10 | | | | | 36 | |
| | | 2 | Electrical Drawing Recognition and Circuit Inspection and Repair | 4 | 72 | 10 | 62 | | | | | 72 | |

**Table 4.13** (Continued)

| Course category | No | Course Title | Semester | | | | Semester/Hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | 3 | Mechanical Drawing and Sugar Making Equipment Management | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 4 | Practical Operation of Electrical and Electronic Technology | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 5 | Installation and Debugging of Non-standard Electromechanical Products | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 6 | Motor Drive Technology | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 7 | PLC Engineering Training | 4 | 72 | 10 | 62 | | | | | | 72 |
| | 8 | Smart Manufacturing Production Line Maintenance | 4 | 72 | 10 | 62 | | | | | | 72 |
| | 9 | Productive Training | 30 | 576 | 0 | 576 | | | | | | 576 |
| | Total | | 145 | 2790 | 1118 | 1672 | 446 | 420 | 398 | 406 | 396 | 720 |

In order to test the practical ability of students majoring in electrical automation technology, the "Practical Ability Assessment Question Bank for Students Majoring in Electrical Automation Technology" was designed. For the 10 core abilities that employers are concerned about, 10 questions are set for each ability, totaling 100 questions, and the above questions are placed on the Xuexitong website. When taking the exam, students log in to the website, and the system will randomly select 1 question for each ability to assess the students, totaling 10 questions, with a total score of 100 points.

Experimental results analysis

The results of the pre-test and post-test of the two classes are shown in the table.

**Table 4.14** Overview of pre-test and post test scores

| Student ID | Pre test score | Post test score | Student ID | Pre test score | Post test score |
|---|---|---|---|---|---|
| Class 1 (control group) | | | Class 2 (control group) | | |
| 1 | 49 | 66 | 1 | 47 | 87 |
| 2 | 52 | 78 | 2 | 50 | 80 |
| 3 | 52 | 75 | 3 | 49 | 75 |
| 4 | 50 | 77 | 4 | 50 | 80 |
| 5 | 53 | 76 | 5 | 47 | 83 |
| 6 | 51 | 78 | 6 | 46 | 81 |
| 7 | 49 | 77 | 7 | 54 | 83 |
| 8 | 46 | 70 | 8 | 48 | 76 |
| 9 | 49 | 72 | 9 | 49 | 85 |
| 10 | 50 | 77 | 10 | 51 | 75 |
| 11 | 52 | 70 | 11 | 51 | 82 |
| 12 | 53 | 74 | 12 | 49 | 83 |
| 13 | 51 | 66 | 13 | 51 | 85 |
| 14 | 51 | 83 | 14 | 50 | 89 |

**Table 4.14** (Continued)

| Student ID | Pre test score | Post test score | Student ID | Pre test score | Post test score |
|---|---|---|---|---|---|
| 15 | 52 | 75 | 15 | 47 | 81 |
| 16 | 47 | 75 | 16 | 45 | 77 |
| 17 | 43 | 71 | 17 | 48 | 86 |
| 18 | 53 | 82 | 18 | 53 | 94 |
| 19 | 49 | 77 | 19 | 46 | 81 |
| 20 | 50 | 72 | 20 | 53 | 92 |

1. Pre-test data analysis

First, the difference in academic performance between the experimental group and the control group was analyzed. The students' practical ability scores were tested using the "Practical Ability Assessment Question Bank for Students in Electrical Automation Technology Majors", and the experimental results were analyzed. The analysis results are used to determine whether the students in the experimental group and the control group are homogeneous in the practical ability dimension.

The pre-test scores of the practical ability of the experimental group and the control group were statistically analyzed, as shown in Table 4.15.

**Table 4.15** Pre-test and post-test results statistics

| | Mean | Number of samples | Standard deviation |
|---|---|---|---|
| Pre-test scores of the experimental group | 49.2 | 20 | 2.505 |
| Pre-test scores of the control group | 50.1 | 20 | 2.553 |

As can be seen from the above table, the average pre-test score of the experimental group is 49.2, and the average pre-test score of the control group is 50.1.

The independent sample t-test results of the pre-test scores of students in the experimental group and the control group are analyzed, as shown in Table 4.16.

**Table 4.16** Results of t-test analysis

| **Analysis items** | **Item** | **Sample size** | **Mean** | **Standard deviation** | **Difference between means** | **Difference 95% CI** | ***t*** | ***df*** | ***p*** |
|---|---|---|---|---|---|---|---|---|---|
| Pre-test results | Sample group | 20 | 49.20 | 2.50 | -0.90 | -2.519 ~ 0.719 | -1.125 | 38.000 | 0.267 |
| | Control group | 20 | 50.10 | 2.55 | | | | | |
| | Total | 40 | 49.65 | 2.54 | | | | | |

* *p*<0.05 ** *p*<0.01

From the above table, we can see that the independent sample t test is used to study the differences in the pre-test scores of students in different classes. From the above table, we can see that the pre-test scores of the samples of students in different classes do not show significant differences (p>0.05), which means that the pre-test scores of the students in the sample group or the control group are all consistent and there is no difference.

The above table shows that the pre-test scores of the students in the sample group and the control group do not show significant differences. In short, the pre-test results show that there is no significant difference between the sample group and the control group in terms of practical ability.

2. Post-test data analysis

This study compares the practical ability of students majoring in electrical automation technology under two different teaching modes: the modern practice teaching mode and the traditional teaching mode. This is used to prove the impact of the modern practice teaching mode on the practical ability of students majoring in electrical automation technology.

(1) Analysis of sample group assessment results

The paired sample t-test was performed on the pre- and post-test scores of students' practical ability under the modern practice teaching mode, as shown in Table 4.17.

**Table 4.17** Paired sample t test of students' pre- and post-test scores under the modern practice teaching model

| Pairing number | Item | Mean | Standard deviation | Difference between means | *t* | *p* |
|---|---|---|---|---|---|---|
| Pairing 1 | Pre-test | 49.20 | 2.50 | -33.55 | -31.652 | 0.000** |
| | Post-test | 82.75 | 5.20 | | | |

* $p$<0.05 ** $p$<0.01

Paired t-test is used to study the differences of experimental data. It can be seen from the above table that there are 1 set of paired data, all of which show differences (p<0.05). Specific analysis shows that:

The pre-test and post-test of the practical ability of the sample group students show a significance of 0.01 level (t=-31.652, p=0.000), and the specific comparison shows that the average value of the pre-test is 49.20, which is significantly lower than the average value of the post-test is 82.75. A total of 1 set of paired data will show differences. Therefore, the practical ability of the sample group students has been significantly improved.

Paired sample Wilcoxon analysis of students' practical ability scores under the modern practice teaching model is performed, as shown in Table 4.18.

**Table 4.18** Paired sample Wilcoxon analysis of students' practical ability before and after tests under the modern practice teaching model

| **Name** | **Paired Median M(P25,P75)** | | **Median M difference** | **Statistic** | ***p*** |
|---|---|---|---|---|---|
| | Pairing 1 | Pairing 2 | **(Pairing 1-Pairing 2)** | **z-score** | |
| Pre-test Pairing Post-test | 49.000(47.0,51.0) | 82.500(80.0,85.3) | -33.500 | 3.923 | 0.000** |

* *p*<0.05 ** *p*<0.01

From the table above, we can see that the Wilcoxon signed rank test is used to study the differences in experimental data. From the table above, we can see that:

A total of 1 group of paired data will show differences (p<0.05). Specific analysis shows that: the sample group students' practical ability pre-test and post-test show a 0.01 level of significance (p=0.000<0.01), and the specific comparison shows that the median of the practical ability pre-test (49.000) is significantly lower than the median of the post-test (82.500). It can effectively show that students' practical ability has been significantly improved through learning activities under the modern practice teaching model.

(2) Analysis of the evaluation results of the control group

A paired sample t-test was performed on the pre-test and post-test scores of students' practical ability under the traditional teaching model, as shown in Table 4.19.

**Table 4.19** Paired sample t-test of pre-test and post-test scores of students under the traditional teaching model

| **Pairing number** | **Item** | **Mean** | **Standard deviation** | **Difference between means** | ***t*** | ***p*** |
|---|---|---|---|---|---|---|
| Pairing 1 | Pre-test | 50.10 | 2.55 | -24.45 | -25.018 | 0.000** |
| | Post-test | 74.55 | 4.54 | | | |

* *p*<0.05 ** *p*<0.01

Paired t-test is used to study the differences of experimental data. It can be seen from the above table that there are 1 set of paired data, all of which show differences (p<0.05). Specific analysis shows that:

The practical ability of students in the control group showed a significance of 0.01 level between the pre-test and post-test (t=-25.018, p=0.000), and the specific comparison shows that the average value of the pre-test is 50.10, which is significantly lower than the average value of the post-test is 74.55. A total of 1 set of paired data will show differences. Therefore, the practical ability of students in the sample group is significantly improved under the traditional teaching mode.

The students' practical ability scores under the traditional teaching mode are subjected to paired sample Wilcoxon analysis, as shown in Table 4.20.

**Table 4.20** Paired sample Wilcoxon analysis of students' practical ability before and after tests under the traditional teaching mode

| **Name** | **Paired Median M(P25,P75)** | | **Median M difference** | **Statistic** | *p* |
|---|---|---|---|---|---|
| | Pairing 1 | Pairing 2 | **(Pairing 1-Pairing 2)** | **z-score** | |
| Pre-test Pairing Post-test | 50.500(49.0,52.0) | 75.000(71.8,77.0) | -24.500 | 3.928 | 0.000** |

* *p*<0.05 ** *p*<0.01

As can be seen from the table above, the Wilcoxon signed rank test is used to study the differences in experimental data. From the table above, it can be seen that:

A total of 1 group of paired data will show differences (p<0.05). Specific analysis shows that: the sample group's practical ability pre-test and post-test show a 0.01 level of significance (p=0.000<0.01), and the specific comparison shows that the median of the pre-test is 50.500, which is significantly lower than the median of the post-test is 75.000. A total of 1 group of paired data will show differences.

It can be effectively explained that students have significantly improved their practical ability through learning in the traditional teaching mode. However, compared with the difference between the pre-test and post-test scores of students' practical ability under the modern practice teaching mode, the modern practice teaching mode has a more significant improvement in students' practical ability.

(3) Comparative analysis of the scores of the experimental group and the control group

By conducting an independent sample t-test on the post-test scores of the students in the experimental group and the control group, it is shown whether there are significant differences in the scores of different students, as shown in Table 4.21:

**Table 4.21** t-test analysis results

| **Analysis items** | **Item** | **Sample size** | **Mean** | **Standard deviation** | **Difference between means** | **Difference 95% CI** | ***t*** | ***df*** | ***p*** |
|---|---|---|---|---|---|---|---|---|---|
| Post-test results | Control group | 20 | 74.55 | 4.54 | -8.20 | -11.324 ~ -5.076 | -5.314 | 38.000 | 0.000** |
| | Sample group | 20 | 82.75 | 5.20 | | | | | |
| | Total | 40 | 78.65 | 6.36 | | | | | |

* *p*<0.05 ** *p*<0.01

From the above table, we can see that the independent sample t test is used to study the differences in the post-test scores of the sample group and the control group. From the above table, we can see that the samples of different student groups all show significant results for the post-test scores (p<0.05), which means that the samples of different student categories have differences in the post-test scores. Specific analysis shows that:

The sample group and the control group show a 0.01 level of significance for the post-test scores (t=-5.314, p=0.000), and the specific comparison shows that the average post-test score of the experimental group students is 74.15, and the average post-test score of the sample group students is 65.878, with a difference of 8.272. Through the independent sample T test, we can see that the significance level of the variance homogeneity test is 0.000<0.05, indicating that there is a significant difference in the post-test scores between the experimental group and the control group. As shown in Figure 4.2 and Figure 4.3.

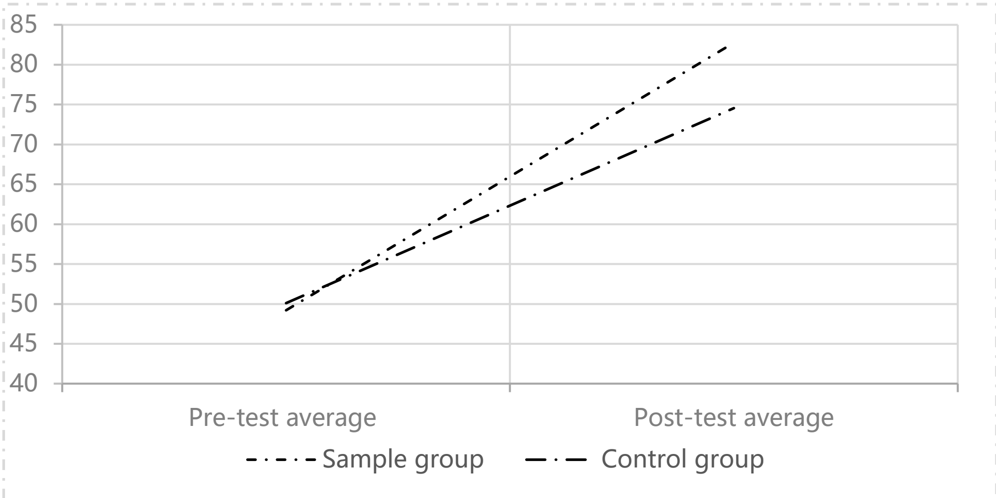


**Figure 4.2** Comparison of average score increments before and after the test

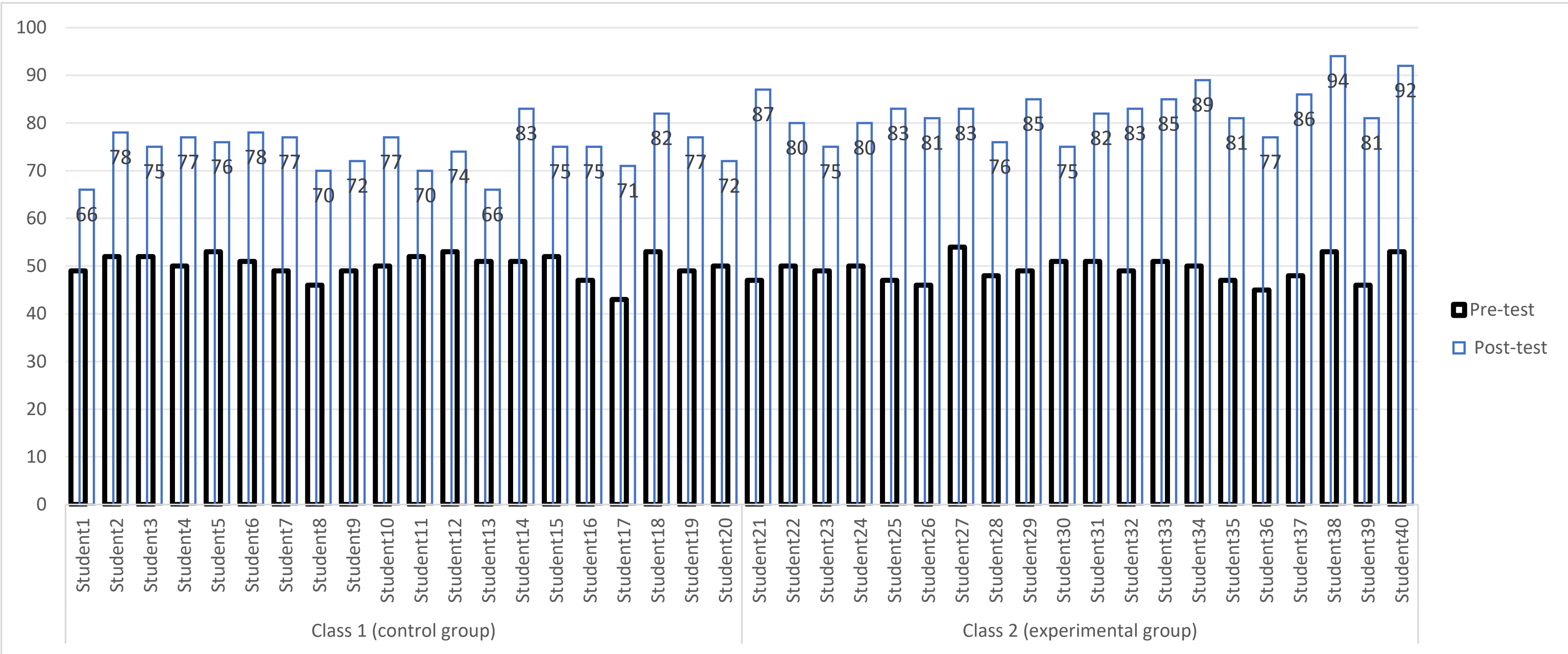


**Figure 4.3** Details of the pre- and post-test scores of students in the experimental and control groups

In summary, it can be seen that there are significant differences in the scores of samples from different student categories after the test. For students majoring in electrical automation technology, after training in modern practical teaching mode, their practical ability score has increased by 68.19%, which is 19.39% higher than that of students trained in traditional teaching mode. Therefore, compared with teaching activities under traditional teaching modes, teaching activities carried out under modern practical teaching modes significantly improve students' practical abilities.

# Chapter 5
# Conclusion Discussion and Recommendations

In the research results of "Modern Practice Teaching Model for Students Majoring in Electrical Automation Technology", the researchers submitted the following relevant literature.

## Conclusion

From the perspective of research objectives

Study the employers' requirements for practical skills of graduates majoring in electrical automation technology: The employers' demand for practical skills of students majoring in electrical automation technology is mainly concentrated in the following 9 aspects: Able to identify and detect commonly used electronic components,Able to read and draw various electrical principles and circuit diagrams,Proficient in using commonly used instruments and meters,Proficient in using commonly used electrical tools,Able to design and analyze low-voltage electrical circuits,Able to install and debug PLC control systems,Able to troubleshoot PLC control system faults,Able to install and debug low-voltage electrical circuits,Able to recognize and draw mechanical structure diagrams.

1. In the analysis of the survey results, the $\mu$ value of these items is between 4.55-4.80, and the $\sigma$ value is between 0.69-0.86. Although the companies participating in the survey differed in size, industry and geography, they showed remarkable consistency in their demand for nine key practical skills required by students majoring in electrical and automation technology. This general consensus highlights the central role of these skills in professional education and is something that schools should pay special attention to when formulating teaching plans.

2. The researchers conducted an in-depth analysis of the nine core practical skills required for electrical automation technology majors and divided them into three levels of modules: the first is the basic module, which focuses on drawing reading, drawing skills and identification of electronic components; The second is the

improvement module, covering the design, installation and debugging of electrical circuits; the last is the comprehensive module, including the assembly, calibration and maintenance of complex control systems. This hierarchical modular design ensures that students can smoothly transition to more advanced learning stages after mastering basic knowledge and skills.

Based on the nine competencies of these three modules, the research team worked with college teachers, industry experts and educational managers to jointly build a modern practice teaching model. The implementation strategy of this model covers many aspects such as course structure design, teaching standard formulation, teaching staff construction, and practical training facility planning, etc., aiming to provide students with a systematic and practice-oriented learning path.

24 experts from 5 different fields conducted a questionnaire survey on the above-mentioned teaching model of modern practice. This is used to reflect the attitudes of individuals in different fields towards the apprenticeship teaching model. The average score of the 18 items to be evaluated ranges from 4.365 to 4.917, and the standard deviation ranges from 0.282 to 0.770. After evaluation by 24 experts, the environmental design of the modern practice teaching model is relatively reasonable.

3. Analyze students’ professional practical abilities under the traditional teaching model and the apprenticeship teaching model through pre- and post-tests and comparative tests. The results showed that the pretest scores of student samples from different classes did not show significant differences ($p>0.05$). There is a significant difference in the post-test scores between the experimental group and the control group, but the average post-test score of students in the experimental group is 74.15, and the average post-test score of students in the sample group is 65.878, with a difference of 8.272. For students majoring in electrical automation technology, after training in modern practical teaching mode, their practical ability score has increased by 68.19%, which is 19.39% higher than that of students trained in traditional teaching mode.

This is consistent with the research hypothesis, indicating that after the implementation of the modern practice teaching model, students' professional practical abilities will be improved more significantly. Therefore, it can be concluded that the modern practice teaching model is very effective in improving the practical ability of students majoring in electrical automation technology.

## Discussion

From the analysis of the collected data, corporate employers have clear requirements for the practical ability of students majoring in electrical automation technology, and students must master relevant skills to be competent for the work of the company. Moreover, enterprises from different regions and industries have basically consistent requirements for the practical ability of graduates of this major.

1. From the data of the questionnaire survey, some employers also chose the three abilities of "being able to write PLC programs", "being able to maintain industrial robots", and "being able to debug industrial networks", but the proportion is not the highest. This shows that there is a demand for these three abilities in the production and management sites of some enterprises, but this is not the most common situation in the industry. Therefore, employers can enable students to master these abilities through later training after students join the company to meet the personalized needs of different enterprises (Casner-Lotto, J., & Barrington, L. 2006). This is not within the scope of this study. In short, according to the general needs of employers, understanding their needs for the practical ability of students majoring in electrical automation technology is the most important and critical step, which is designed to the research direction of the next few steps (Mardis, M. A et al., 2018).

2. A modern practice teaching model was designed for the 9 practical abilities that employers are most concerned about. The principle of the modern practice teaching model was unanimously recognized by 5 experts (practicality, feasibility, appropriateness and accuracy). This shows that the theory and principle of this model are reasonable and conducive to improving students' practical ability.

In the detailed analysis, it is worth noting that: a questionnaire survey was conducted on 24 experts of different identities, namely enterprise engineers, teachers of higher vocational schools, enterprise HR, vocational education experts and teaching management personnel of higher vocational schools. The results show that they unanimously recognized the 18 components involved in the modern practice teaching model and believed that it was suitable for further implementation.

3. The experts unanimously affirmed the feasibility of the modern practice implementation plan. The modern practice teaching model was verified by the methods of pre-test and post-test and comparative test. The results show that the modern practice teaching model is more effective in improving the practical ability of electrical automation technology majors than the traditional teaching model. The reasons for this are mainly the following two aspects:

Combining practice with theory: The modern practice teaching model emphasizes the close integration of theoretical knowledge with practical operations. Students learn in the real environment of the enterprise and directly participate in the installation, commissioning and maintenance of automation equipment. This "learning by doing" method enables students to understand theoretical knowledge more intuitively and quickly apply what they have learned to practice, thereby effectively improving their practical skills and ability to solve practical problems (Cheetham, G., & Chivers, G. 2001).

Enterprise participation and dual mentor system: Under the modern practice model, enterprises deeply participate in the teaching process, provide internship opportunities and training facilities. Students learn under the joint guidance of enterprise mentors and school teachers. This "dual mentor system" ensures a high degree of consistency between teaching content and enterprise needs. The practical experience and professional skills imparted by enterprise mentors enable students to obtain guidance that is closer to actual work needs, enhancing the pertinence and effectiveness of teaching (Ren, N., & Zhao, J. 2023).

These reasons work together to make the modern practice teaching model show significant advantages in cultivating the practical ability of students majoring in electrical automation technology, and provide strong support for the comprehensive development of students majoring in electrical automation technology.

In short, the modern practice teaching model has a significant effect on improving students' practical ability. The modern practice teaching model has been proven to be an effective way to improve the practical ability of students majoring in electrical automation technology. After implementing this model, most students have achieved good results.

## Recommendations

Suggestions for students:

1. Actively participate in practical activities: Students should make full use of the opportunities provided by the modern practice system and actively participate in corporate internships and practical activities. Through practical operations, combine theoretical knowledge with practical skills to improve their professional skills.

2. Active learning and exploration: During the apprenticeship period, students should maintain an active learning attitude and constantly explore new knowledge and new technologies. Use corporate resources to learn the latest industry trends and enhance their competitiveness.

3. Focus on the combination of theory and practice: Students should recognize the relationship between theory and practice and deepen their understanding of theoretical knowledge through practice. When encountering problems in practice, take the initiative to seek solutions and improve problem-solving ability.

4. Cultivate innovative thinking: During the apprenticeship learning process, encourage students to give full play to their innovative spirit and try new methods and new ideas. Innovation is the key to promoting personal and industry development. Students should constantly challenge themselves and cultivate innovative ability(Tanggaard, L. 2018).

5. Pay attention to the cultivation of professional literacy: In addition to professional skills, professional literacy is equally important. Students should learn through apprenticeship, cultivate good professional ethics, work attitude and professional habits, and lay a solid foundation for their future career(Tian, J., Gong, P., & Zhang, L. 2017).

6. Lifelong learning awareness: Apprenticeship learning is not only learning during school, but also a part of lifelong learning. Students should establish the concept of lifelong learning, constantly update their knowledge, and adapt to the ever-changing working environment.

**Suggestions for Teachers:**

1. Strengthen the role of dual mentors: As school teachers, they should work closely with enterprise mentors to guide students together to ensure that students can develop in a balanced way in professional knowledge and practical skills.

2. Continuous professional development: Teachers should constantly update their professional knowledge and teaching methods to meet the requirements of the modern practice teaching model and keep the teaching content cutting-edge and practical(Richter, D. et al., 2014).

3. Pay attention to individual differences among students: During the teaching process, teachers should pay attention to the characteristics and needs of each student, provide personalized guidance and support, and help students overcome difficulties in learning.

4. Promote communication between schools and enterprises: Teachers should serve as a bridge between schools and enterprises, strengthen communication and collaboration between the two sides, and ensure that the teaching content matches the actual needs of enterprises.

5. Evaluation and feedback: Regularly evaluate students' learning progress and practical ability, provide timely feedback, and help students recognize their strengths and areas for improvement (Irons, A., & Elkington, S. 2021).

**Suggestions for Schools:**

1. Combine courses with enterprise practice: Schools should design courses to closely integrate with enterprise practice to ensure that students can learn and apply knowledge in a real working environment.

2. Establish a school-enterprise cooperation mechanism: Schools should establish long-term and stable cooperative relations with enterprises, jointly develop courses, provide internship opportunities, and create more practical platforms for students (Xu, L., & Linuo, S. 2020).

3. Teacher team construction: Strengthen the construction of the teaching staff, especially the training of dual-qualified teachers, and improve teachers' practical teaching ability.

4. Provide resource support: Schools should provide necessary teaching resources and facilities, including training bases, laboratories and teaching tools, to support the implementation of the modern practice teaching model.

5. Strengthen quality monitoring: Establish and improve the teaching quality monitoring system, regularly evaluate and review teaching activities, and ensure the effectiveness and quality of the teaching model.

6. Promote the all-round development of students: Pay attention to the all-round development of students, provide career planning, employment guidance and psychological counseling services, and help students smoothly transition to the workplace.

7. Continuously improve the teaching model: According to feedback and evaluation results, continuously improve the modern practice teaching model to adapt to changes in education development and the labor market (Muijs, D., & Reynolds, D. 2017).

## Future Research

1. Continuous optimization of the modern practice teaching model: Research on how to further optimize the modern practice teaching model to adapt to the changing educational needs and corporate needs.

2. Research on the impact of teaching models on student employment: Research on the impact of the modern practice teaching model on student employment rate and employment quality.

3. Exploration of interdisciplinary teaching models: Explore the promotion of the modern practice teaching model for electrical automation technology majors to other majors to improve students' comprehensive abilities.

# References


Ashman, K., Rochford, F., & Slade, B. (2021). **Work-Integrated Learning: The new professi-onal apprenticeship?.** Journal of University Teaching & Learning Practice, 18(1), 5. Htt-ps://ro.uow.edu.au/jutlp/vol18/iss1/5/

Anderson, T., & Metcalf, H. (2003). **Modern Apprenticeship Employers: Evaluation Study.** London: Department for Education and Skills. http://www.education.gov.uk/publications/eOrderingDownload/ACF4B9.pdf

Australia. Prime Minister, Keating, P., & Beazley, K. C. (1992). **A national employment and training plan for young Australians.** Canberra: Australian Government Publishing Serv-ice. https://www.voced.edu.au/content/ngv:15894

Bi Yan. (2014). **Some thoughts on the pilot of the modern apprenticeship system in vocational education.** China Higher Vocational Education Network. https://wenku.baidu.com/view/206b8e981b37f111f18583d049649b6648d70979?fr=xueshu_top&_wkts_=1724652972974&needWelcomeRecommand=1

People's Daily Client. (Ed.) (2018). **Chen Baosheng: Promote the Pilot of Modern Apprentic-eship Aystem and Establish More Than 1,400 Vocational Education Industry Groups.** http://news.haiwainet.cn/n/2018/0316/c3543388-31280182.html?baike

Cantor, J. A. (1997). **Cooperative Apprenticeships. A School-to-Work Handbook**. Technomic Publishing Company, 851 New Holland Avenue, Box 3535, Lancaster, PA 17604; 800/233-9936. https://eric.ed.gov/?id=ED405471

Cheetham, G., & Chivers, G. (2001). **How professionals learn in practice: an investigation of informal learning amongst people working in professions.** Journal of European Industri-al Training, 25(5), 247-292. https://www.emerald.com/insight/content/doi/10.1108/03090590110395870/full/html

Casner-Lotto, J., & Barrington, L. (2006). **Are they really ready to work? Employers' perspe-ctives on the basic knowledge and applied skills of new entrants to the 21st century US workforce.** Partnership for 21st Century Skills. 1 Massachusetts Avenue NW Suite 700, Washington, DC 20001. https://eric.ed.gov/?id=ED519465

General Office of the State Council(Ed.) (2014). **Li Keqiang presided over the State Council executive meeting (February 26, 2014).** https://www.gov.cn/guowuyuan/2014-02/26/co-ntent_2622744.htm

Dell'Olio, J. M., & Donk, T. (2007). **Models of teaching: Connecting student learning with st-andards.** Sage Publications. https://books.google.co.th/books?hl=zh-CN&lr=&id=FQRzAwAAQBAJ&oi=fnd&pg=PP1&dq=Models+of+teaching:+Connecting+student+learning+with+%09standards.&ots=04zkt7eOWo&sig=X3evwOfqZTsvIiPBBychuMM7KXw&redir_esc=y#v=onepage&q=Models%20of%20teaching%3A%20Connecting%20student%20learning%20with%20%09standards.&f=false

Dictionary Office of the Institute of Language, Chinese Academy of Social Sciences. (1996). **The revised version of the Modern Chinese Dictionary**. The Commercial Press.894.

Duo Shujie. (2016). **Institutional Dilemma and Breakthrough of Enterprise Participation in Vocational Education in my country: On the Development and Enlightenment of Modern Apprenticeship System in Germany.** China Vocational and Technical Education (24), 5-10. https://CNKI:SUN:ZONE.0.2016-24-001.

European Centre for the Development of Vocational Training. (2008). **Terminology of Europ-ean education and training policy: a selection of 100 key terms.** Publications Office. https://www.cedefop.europa.eu/files/4064_en.pdf

European Commission. Directorate-General for Employment, Social Affairs and Inclusion IKEI Research and Consultancy (Firm). (2012). **Apprenticeship supply in the member states of the European Union.**

EU Commission. (2012). **Apprenticeship supply in the member states of the European Union.** https://op.europa.eu/en/publication-detail/-/publication/3b34aeca-d9bb-4ac1-a3dc-d106e43bc2bf

Fuller, A., & Unwin, L. (2011). Apprenticeship as an evolving model of learning. **Journal of Vocational Education & Training, 63**(3), 261-266. https://www.tandfonline.com/doi/full/10.1080/13636820.2011.602220

Feng Fang. (2016). A new form of foreign school-enterprise cooperation A review of moder-n apprenticeship. China Professionals Association's 2016 Outstanding Scientific Research Achievement Award Proceedings (Second Prize of School).

Feng Fang. (2016). **New forms of school-enterprise cooperation abroad - a review of modern apprenticeship. Secretariat of the China Association of Workers' Education and Vocational Training.** (eds.) Collection of award-winning papers on outstanding scientific research results of the China Association of Workers' Education and Vocational Training in 2016 (Second Prize for Schools) (pp. 2512-2517).

Feng Kecheng and Xi Erxiao. (1994). **A Complete Book on Practical Classroom Teaching M-odels and Methods Reform,** Central Compilation and Translation Press.

Fuller, A., & Unwin, L. (2003). Creating a'Modern Apprenticeship': a critique of the UK's m-ulti-sector, social inclusion approach. **Journal of Education and Work, 16**(1), 5-25. https://www.tandfonline.com/doi/abs/10.1080/1363908022000032867

Greig, M. (2019). Factors affecting modern apprenticeship completion in Scotland. **International Journal of Training and Development, 23**(1), 27-50. https://onlinelibrary.wiley.com/doi/abs/10.1111/ijtd.12142

Guan Jing & Shi Weiping. (2011). Characteristics and enlightenment of modern apprenticeship system in the West. **Vocational and Technical Education** (31), 77-83. https://CNKI:SUN:ZYJW.0.2011-31-019.

He Kekang, Li Kedong, Xie Youru, Wang Benzhong. (2000). Theoretical basis of the leadersubject teaching model. **Audiovisual Education Research** (02), 3-9. https://10.13811/j.cnki.eer.2000.02.001.

Hu Xiujin (2009). Research on the Talent Training Model of Modern Apprenticeship System **Journal of Hebei Normal University (Education Science Edition)** (03), 97-103.https://10.13763/j.cnki.jhebnu.ese.2009.03.025.

Harris, M. (2003). Modern Apprenticeships: An assessment of the government’s flagship training programme. IoD policy paper, Institute of Directors, London.(8):18-19

Harris, M. (2003). **Modern Apprenticeships: An Assessment of the Government's Flagship Tr-anining Programme.** Institute of Directors. https://www.voced.edu.au/content/ngv:81621

Irons, A., & Elkington, S. (2021). **Enhancing learning through formative assessment and feedback.** Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9781138610514/enhancing-learning-formative-assessment-feedback-alastair-irons-sam-elkington

Jia Wensheng, Xu Jian, and Shi Weiping (2021). Preliminary exploration of the motivation for enterprises to participate in the reform of modern apprenticeship system in vocational colleges. **China Higher Education Research** (06), 103-108.https://10.16298/j.cnki.1004-3667.2021.06.17.

Knight, B. (2012). **Evolution of Apprenticeships and Traineeships in Australia: An Unfinish-ed History. Occasional Paper.** National Centre for Vocational Education Research Ltd. PO Box 8288, Stational Arcade, Adelaide, SA 5000, Australia. https://eric.ed.gov/?id=ED529636

Li Rumi. (1996). Discussion on Several Theoretical Issues of Teaching Mode. **Curriculum,Textbooks, and Teaching Methods** (04). https://10.19877/j.cnki.kcjcjf. 1996.04.004.

Li Shiyan (1984). Models and Modeling Methods. **Philosophical Research** (09), 45-51.https://CNKI:SUN:ZXYJ.0.1984-09-006.

Liu Wei (2008). Construction of seminar based teaching mode. **Higher Education Research** (10), 65-67. https://CNKI:SUN:HIGH.0.2008-10-012.

Li Bingde. (1991). Teaching Theory. **People's Education Press.**

Lin Xiaowei (2019). **Research on the 6T Model for Cultivating High skilled Talents in Mechanical and Electrical Engineering Based on Modern Apprenticeship System** [Master dis-sertation, Zhejiang University of Technology]https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202001&filename=1019953335.nh

Lu Gusun, **English Chinese Dictionary,** Shanghai: Shanghai Translation Publishing House, 1993: 1153

Li Chuanwei, Dong Xian, and Jiang Yi (2015). **Research and Practice on the Educational Mechanism of Modern Apprenticeship Training Model.** Vocational Education Forum (09), 75-77.https://CNKI:SUN:ZJLT.0.2015-09-017.

Lu Wanyu (2011). **Research on the Talent Training Model of "Modern Apprenticeship System" in Higher Vocational Education** [Master dissertation, Dalian University] https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD2011&filename=1011160494.nh

Li Qingqing (2013). **Research on External Environmental Protection Strategies for Modern Apprenticeship System in Vocational Colleges** [Master dissertation, Southwest Universi-ty] https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201302&filename=1013270382.nh

Li Xiang (2015). **Research on the Current Situation and Countermeasures of Implementing Modern Apprenticeship System in Vocational Colleges**. Journal of Changzhou University (Social Sciences Edition) (01), 121-124.hppts//:CNKI:SUN:JSSB.0.2015-01-024.

Ding Tingsen (1990). **International Encyclopedia of Education.** Guizhou Education Press

Li Yuexing (2017). **Research on the functions of guilds in medieval England (1100-1400)** [Master dissertation, Central China Normal University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201801&filename=1017254865.nh

Liu Xiao. (2011). **A Brief History of the Development of Apprenticeship System in China.** Vocational and Technical Education (09), 72-75.https://CNKI:SUN:ZYJW.0.2011-09-030.

Lu Yongwei. (2014). **Reform and practice of talent training mode combining vocational education and learning in higher education: Taking the electrical automation technology major of Guangxi Vocational and Technical College as an example.** Education Exploration (04), 70-71. https://CNKI:SUN:SEEK.0.2014-04-033.

Mitchell, G. (2017). **A new dictionary of the social sciences.** Routledge. https://doi.org/10.4324/9781315083353

Murray, N. (2002). Modern Apprenticeship: What's in a name?. Labour, **Employment and Work in New Zealand.** https://ojs.victoria.ac.nz/lew/article/view/1231

Mardis, M. A., Ma, J., Jones, F. R., Ambavarapu, C. R., Kelleher, H. M., Spears, L. I., & McClure, C. R. (2018). Assessing alignment between information technology educational opportunities, professional requirements, and industry demands. **Education and Information Technologies, 23,** 1547-1584. https://link.springer.com/article/10.1007/s10639-017-9678-y

Maguire, M. (1998). Modern apprenticeships and employers. **Journal of Vocational Education & Training, 50**(2), 247-259. https://www.tandfonline.com/doi/abs/10.1080/13636829800200047

Molz, A. (2015). Delivering TVET through quality apprenticeships. **In Report of the UNESC-O-UNEVOC virtual conference** (p.12-18). https://unevoc.unesco.org/e-forum/BackgroundNote-VC-Apprenticeship-Molz.pdf

Modern Apprenticeship (Ed.) (2019). **In Baidubaike.** https://baike.baidu.com/item/%E7%8E%B0%E4%BB%A3%E5%AD%A6%E5%BE%92%E5%88%B6?fromModule=lemma_search-box

Muijs, D., & Reynolds, D. (2017). **Effective teaching: Evidence and practice**. Sage. https://books.google.co.th/books?hl=zh-CN&lr=&id=apc3DwAAQBAJ&oi=fnd&pg=PP1&dq=Muijs,+D.,+%26+Reynolds,+D.+(2017).+Effective+teaching:+Evidence+and+practice&ots=dwW0iarbXq&sig=DQqf38OrMAzaEgkTVkjbcmAHoxE&redir_esc=y#v=onepage&q=Muijs%2C%20D.%2C%20%26%20Reynolds%2C%20D.%20(2017).%20Effective%20teaching%3A%20Evidence%20and%20practice&f=false

Ministry of Industry and Information Technology of the People's Republic of China (Ed.) (2016). ***Smart Manufacturing Development Plan***. https://www.miit.gov.cn/zwgk/zcwj/wjfb/zbgy/art/2020/art_ef82844f3d864b44906f72bdd2eb14d8.html.

Ministry of Education of the People’s Rupublic of China(Ed.) (2017). **Notice from the Gener-al Office of the Ministry of Education on the Announcement of the Second Batch of Mod-ern Apprenticeship Pilot Programs and the Annual Inspection Results of the First Batch of Pilot Programs.** Office of the Ministry of Education. http://www.moe.gov.cn/srcsite/A07/moe_737/s3876_cxfz/201709/t20170911_314178.html

Ministry of Education of the People's Rupublic of China (Ed.) (2019). **Notice from the Gener-al Office of the Ministry of Education on the Comprehensive Promotion of Modern Apprenticeship System**. Office of the Ministry of Education. http://www.moe.gov.cn/srcsite/A07/s7055/201906/t20190603_384281.html?eqid=c%*2037e36ae0007ad2d000000026441dec5*

Ministry of Education of the People's Rupublic of China(Ed.) (2015). **Notice from the Gener-al Office of the Ministry of Education on the Announcement of the First Batch of Pilot Units for Modern Apprenticeship System.** Office of the Ministry of Education. http://www.moe.gov.cn/srcsite/A07/moe_737/s3876_cxfz/201508/t20150817_200588.html

Minstry of Finance of the People's Republic of China (Ed.). (2015). **Notice on Carrying out P-ilot Work of New Apprenticeship System in Enterprises.** Office of the Ministry of Finance. http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201508/t20150805_1405492.htm

Postlethwaite, T. N., & Husen, T. (Eds.). (1994). **The International Encyclopedia of Education: 12-Volume Set.** Pergamon. 1069-1081

Peng Siheng (2015). **Discussion on the Implementation Process of Modern Apprenticeship Talent Training Model in Vocational Colleges.** Shang (41), 29-30.https://CNKI:SUN:SHNG.0.2015-41-027.

Richter, D., Kunter, M., Klusmann, U., Lüdtke, O., & Baumert, J. (2014). Professional development across the teaching career: Teachers' uptake of formal and informal learning opportunities. **In Teachers' professional development** (pp. 97-121). Brill. https://brill.com/display/book/edcoll/9789462095366/BP000008.xml

Ray, J. (2001). **Apprenticeship in Australia: An Historical Snapshot. Australian Apprentices-hips**. National Centre for Vocational Education Research, 252 Kensington Road, Leabrook, South Australia 5068, Australia. https://eric.ed.gov/?id=ED453398

Ren, N., & Zhao, J. (2023). Establishing a'Dual-Teacher'Teaching Team as an Implementati-on Path for Cultivating High-Quality Technical and Skill Talent within the Visionary T-alent Development Framework. **Journal of Education and Educational Research, 3**(2), 233-236. https://drpress.org/ojs/index.php/jeer/article/view/9311

Ryan, P., Wagner, K., Teuber, S., & Backes-Gellner, U. (2010). **Trainee pay in Britain, Ger-many and Switzerland: markets and institutions.** https://ora.ox.ac.uk/objects/uuid:86be9851-82ab-45f9-a675-727332463fe7

Ryan, P., & Unwin, L. (2001). Apprenticeship in the British ‘training market’. **National insti-tute Economic review, 178,** 99-114. https://www.cambridge.org/core/journals/national-institute-economic-review/article/abs/apprenticeship-in-the-british-training-market/9D026F1B79ACD541C0DA7879B1808EA2

Shi Yongyang (2019). **Research on the Improvement of "Dual Mentor" Team Building in Vocational Colleges under the Background of Modern Apprenticeship System** [Master dissertation, Guangxi University] https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202001&filename=1020729720.nh

Scotland SD. (2013). **Modern apprenticeship outcomes 2012**. Skills Development Scotland.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. **Educational researcher, 27**(2), 4-13. https://journals.sagepub.com/doi/abs/10.3102/0013189X027002004

Steedman, H. (2012). Overview of apprenticeship systems and issues ILO Contribution to the G20 Task Force on Employment. **International Labour Organization.** https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2283123

The Central People's Government of the People's Republic of China (Ed.) (2014). **Opinions of the Ministry of Education on Carrying out Pilot Work of Modern Apprenticeship Syste-m.** Ministry of Education. https://www.gov.cn/xinwen/2014-09/05/content_2745818.htm

Tian, J., Gong, P., & Zhang, L. (2017, December). Research on the ways of cultivating stude-nts' professional quality in Higher Vocational Education. **In 4th International Conference on Education, Management, Arts, Economics and Social Science (ICEMAESS 2017)** (p.246-249). Atlantis Press. https://www.atlantis-press.com/proceedings/icemaess-17/25887228

Tanggaard, L. (2018). Creativity in higher education: Apprenticeship as a “Thinking Model” for bringing back more dynamic teaching and research in a university context. **Sustainable Futures for Higher Education: The making of knowledge makers,** 263-277. https://link.springer.com/chapter/10.1007/978-3-319-96035-7_22

Tu Wanli (2018). **Research on the Modern Apprenticeship Talent Training Model Based on Mechanical Processing and Manufacturing** [Master dissertation, Tianjin Vocational and Technical Normal University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201902&filename=1019601632.nh

The People’s Government of Guangxi Zhuang Autonomous Region.(2021). **Guangxi's 14th Five-Year Development Plan and Vision for 2035.** http://www.gxzf.gov.cn/zfwj/zxwj/t8687263.shtml.

Wang Zhenhong & Cheng Jun. (2012). **Modern apprenticeship system: a new paradigm for training high-skilled talents.** China Higher Education Research (08), 93-96. https://10.16298/j.cnki.1004-3667.2012.08.020.

Wu Yexian. (1988). *A brief discussion on classroom teaching model*. Educational Research and Experiment (01), 12-15. https://CNKI:SUN:YJSY.0.1988-01-003.

Wang Wenjing. (2002). Research on Teaching Model Based on Situational Cognition and Learning. (Doctoral dissertation, East China Normal University).

Wang Wenjing. (2002). **Research on teaching model based on situational cognition and learning** [Doctoral dissertation, East China Normal University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CDFD9908&filename=2003033343.nh

Wang Xing. (2014). The Social Construction of Skill Formation: A Sociological Analysis of the Evolution of China's Factory Master-Apprentice System: a sociology approach to th-e evolving trajec. **Social Science Literature Publishing House.** 224-225

Wang Cesan, Pei Dina, Cong Lixin. (2002). Teaching Epistemology. Revised Edition. **Beijing Normal University Press.**

Xia Z.n. (2000). **Ci Hai: 1999 Edition in Miniature**. Shanghai Dictionary Publishing House. 596.

Xu Jicun, Wang Chuanjin. (2000). **Research on teaching model:** *Where to go*. Journal of Kes-han Teachers College (02), 75-83. https://CNKI:SUN:PYXK.0.2000-02-022.

Xu Cong. (2014). **Analysis of factors affecting German enterprises' participation in dual voc-ational education.** Vocational and Technical Education (16), 85-89. https://CNKI:SUN:ZYJW.0.2014-16-017.

Xu, L., & Linuo, S. (2020, November). Analysis on the construction of long-term mechanism of school enterprise cooperation in the integration of industry and education. **In 2020 International Signal Processing, Communications and Engineering Management Conference (ISPCEM***)* (pp. 105-107). IEEE. https://ieeexplore.ieee.org/abstract/document/9480929

Xiong Yu, Ren Juanping, Huang Hao & Yan Huacheng. (2014). **Exploration and practice of modern apprenticeship talent training model in higher vocational colleges.** Occupational Space (09), 85-87+90. https://CNKI:SUN:XZQJ.0.2014-09-029.

Xiao Yi. (2022). **Measures and implications for the construction of the quality assurance system of modern apprenticeship in the UK.** Vocational Education Research (03), 78-84. https://CNKI:SUN:JLKF.0.2022-03-014.

Xie Junhua. (2013). **Discussion on the talent training model of modern apprenticeship system in higher vocational colleges**. Vocational Education Forum (16), 24-26. https://CNKI:SUN:ZJLT.0.2013-16-006.

Xie Youru. (2000). **Research on new teaching model.** Audio-visual Education Research (01), 11-13. https://10.13811/j.cnki.eer.2000.01.003.

Xia Panpan. (2016). **A Study of Craft Guilds in Late Medieval London** [Master dissertation, Anhui Normal University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201701&filename=1016307623.nh

Yuan Weixin. (2003). **Concept transformation learning: a scientific teaching model based on constructivism.** Foreign Education Research (06), 22-27. https://CNKI:SUN:WGJY.0.2003-06-005.

Yang Xiaoyan. (2012). **Exploration and practice of modern apprenticeship system.** Vocational Education Forum (09), 17-20. https://CNKI:SUN:ZJLT.0.2012-09-006.

Zang, Z. (2013). **A comparative study of national systems of vocational education** [Doctoral dissertation, East China Normal University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CDFD1214&filename=1013272793.nh

Zha Youliang. (2001). Classroom Model Theory. **Guangxi Normal University Press.**

Zhong Zhixian. (2001). **What is new about the new teaching model (Part 1).** Audio-visual Education Research (03), 8-15. https://10.13811/j.cnki.eer.2001.03.002.

Zhang Xuxiang, Shi Zebo & Ding Tao. (2010). **Exploring the design of higher vocational teaching model from the perspective of knowledge management.** Vocational Education Forum (33), 4-7. https://CNKI:SUN:ZJLT.0.2010-33-003.

Zhong Qiquan. (2002). Teaching Model Theory. **Shanghai: Shanghai Education Press.**

Zhang Wusheng. (2000). **Research on creative thinking and individual teaching model.** Journal of Tianjin Academy of Educational Science (05), 31-35. https://10.16137/j.cnki.cn12-1303/g4.2000.05.007.

Zhang Qifu. (2015). **Piloting the modern apprenticeship system in higher vocational college-s: Dilemma and practical strategies.** Educational Development Research (03), 45-51. H-ttps://10.14121/j.cnki.1008-3855.2015.03.008.

Zhao Pengfei. (2014). **Practice and understanding of talent training in modern apprenticeship system.** China Vocational and Technical Education (21), 150-154. https://CNKI:SUN:ZONE.0.2014-21-040.

Zhao Zhiqun. (2009). **Work-learning integration and modern apprenticeship in vocational education.** Vocational Education Forum (36), 1. https://CNKI:SUN:ZJLT.0.2009-36-001.

Zhou Zhan, Liu Wantai, Cui Tiantian, Lv Yunong, & Deng Peng. (2022). Exploration of Modern Apprenticeship Education Model Based on Skills Navigation. **Educational Science Development,** 4(7), 98-101.

Zhou Zhan & Cui Tiantian. (2023). **Research on the "dual education" strategy of modern apprenticeship system in school-enterprise under the framework of industry-education integration community: taking new energy equipment technology as an example.** Modern Vocational Education (14), 62-65. https://CNKI:SUN:XDZJ.0.2023-14-016.

Zhu Bin. (2023). **Practical exploration of a new model for training talents in the modern apprenticeship system for electromechanical majors.** Agricultural Machinery Use and Maintenance (02), 133-135. https://10.14031/j.cnki.njwx.2023.02.040.

Zhang Wei. (2019). **Construction of practice bases for agricultural-related majors under the modern apprenticeship system.** Think Tank Times (06), 277-278. https://CNKI:SUN:ZKSD.0.2019-06-173.

Zhang Yong. (2022). **Construction of advanced higher vocational education curriculum system based on modern apprenticeship system**. Vocational Education Forum (06), 60-66. https://CNKI:SUN:ZJLT.0.2022-06-008.

Zhao Huanli, Wang Huabing, Song Xiaoyan & Wang Yan. (2020). **Research on the reform of talent training mode for electrical engineering and automation under the background of new engineering.** Industry and Technology Forum (10), 137-138. https://CNKI:SUN:CYYT.0.2020-10-069.

# Appendix

# Appendix A

# List of Specialists and Letters of Specialists Invitation for IOC Verification

| Name of Experts | Position/Office |
| --- | --- |
| Ph.D. Mongkom Klingajay | President of Robotics, Informatics, and Intelligent control Technology Association (RIITA) |
| Ph.D. Tomeyot Sanevong Na Ayutaya | Lecturer of Computer Animation and Multimedia Department, Phranakhon Rajabhat University |
| Professor Jiang Sizhong | Teacher, Guangxi Vocational and Technical College (14 years of work experience) |
| Associate Professor Lu Danping | Teacher, Guangxi Vocational and Technical College (17 years of work experience) |
| Associate Professor Fang Xiaoju | Teacher, Nanning Vocational and Technical College (13 years of work experience) |

# Appendix B

# Official Letter

Ref.No. MHESI 0643.14/ 1151

Bansomdejchaopraya Rajabhat University

1061 Itsaraparb Hirunrujee

Thonburi Bangkok 10600

9 May 2024

Subject: Invitation to validate research instrument

Dear Ph.D. Mongkorn Klingajay

Mr. Ming Xin is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "A Modern Apprenticeship Teaching Model for Electrical Automation Technologist Student"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Akaranun Asvarutpokin

(Vice Dean of Graduate School for Dean of Graduate School)

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Bansomdejchaopraya Rajabhat University

1061 Itsaraparb Hirunrujee

Thonburi Bangkok 10600

9 May 2024

Subject: Invitation to validate research instrument

Dear Ph.D. Tomeyot Sanevong Na Ayutaya

Mr. Ming Xin is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "A Modern Apprenticeship Teaching Model for Electrical Automation Technologist Student"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Akaranun Asvarutpokin

(Vice Dean of Graduate School for Dean of Graduate School)

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1061 Itsaraparb Hirunrujee

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9 May 2024

Subject: Invitation to validate research instrument

Dear Associate Professor Fang Xiaoju

Mr. Ming Xin is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "A Modern Apprenticeship Teaching Model for Electrical Automation Technologist Student"

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9 May 2024

Subject: Invitation to validate research instrument

Dear Associate Professor Lu Danping

Mr. Ming Xin is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "A Modern Apprenticeship Teaching Model for Electrical Automation Technologist Student"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

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9 May 2024

Subject: Invitation to validate research instrument

Dear Professor Jiang Sizhong

Mr. Ming Xin is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "A Modern Apprenticeship Teaching Model for Electrical Automation Technologist Student"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

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# Appendix C

# Research Instrument

Questionnaire for human resource executives(Objective 1)
Questionnaire for experts (Objective 1)

Conformity Assessment Form of Modern practice teaching model for electrical automation technology (Objective 2)
Questionnaire for experts (Objective 2)

Lesson Plan (Objective 3)
Course plan for modern practice teaching mode and traditional teaching mode of electrical automation major ( Objective 3)
Questionnaire for experts (Objective 3)
2021 Electrical Automation Technology Professional Practical Skills Assessment Plan and Test Paper Database
Questionnaire for experts (Objective 3)

**Questionnaire For Human Resource Executives (Objective 1)**

Directions:
These questionnaires are the instruments for collecting data in 1st phase of the research entitled "modern practice teaching model for students majoring in electrical automation technology" conducted by Ming Xin, a Ph.D. student in Digital Technology Management for Education at Bansomdejchaopraya Rajabhat University under the supervision of Assistant Professor Dr. Prapai Sridama,majoring advisor, Assistant Professor Dr.Kanakorn Sawangcharoen co-advisor.

This questionnaire is divided into 3 sections i.e.
Section 1: Relevant Information of the Respondent
Section 2:The second section of the second section focuses on the practical abilities of students majoring in electrical automation technology by employing enterprises.

The questionnaire type is a closed ended question, which can only be answered by selecting from the provided numbers to the summary rating scale (5 scales).

Section 3 :Further suggestions

The relevant information collected in this questionnaire is only for the research of the topic, and the researcher will keep all information of the respondents confidential.

Answer the questionnaire:

Section1 Relevant Information of the Respondent

Directions:Please put √ into the ☐ according to your owm personal data.

1. Number of employees

   ☐ Less than 200 ☐ 200-500

   ☐ 500-1000 ☐ More than 1000

2. The industry of the company

   ☐ agricultural products processing

   ☐ Aluminum processing industry

   ☐ Chemical industry

   ☐ manufacturing

   ☐ Less than 200

   ☐ food industry

   ☐ electronic industry

3. Company area

   ☐ Guangxi Province

   ☐ Pearl River Delta region

   ☐ Yangtze River Delta region

   ☐ Other regions

Section 2: Questionnaire on employers' demand for practical abilities of students majoring in electrical automation

Directions: Please rate the following practical abilities in the importance level column based on the criteria provided below. Each question can only have one answer to choose from.

5 means VERY IMPORTANT.

4 means IMPORTANT.

3 means NEUTRAL.

2 means UNIMPORTANT.

1 means VERY UNIMPORTANT.

**Table 1 Questionnaire on employers' demand for practical abilities of students majoring in electrical automation**

| Questions | Answers | | | | |
|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 |
| 1. Able to read and draw various electrical principles and circuit diagrams | | | | | |
| 2. Able to process parts | | | | | |
| 3. Able to assemble and debug electronic circuits | | | | | |
| 4. Able to recognize and draw mechanical structure diagrams | | | | | |
| 5. Able to identify and detect commonly used electronic components | | | | | |
| 6. Able to operate CNC machine tools | | | | | |
| 7. Proficient in using commonly used instruments and meters | | | | | |
| 8. Proficient in using commonly used electrical tools | | | | | |

| Questions | Answers | | | | |
|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 |
| 9. Able to design and analyze low-voltage electrical circuits | | | | | |
| 10. Able to install and debug low-voltage electrical circuits | | | | | |
| 11. Able to design C language programs | | | | | |
| 12. Able to program microcontrollers | | | | | |
| 13. Able to write PLC programs | | | | | |
| 14. Selection and driving capability of three-phase asynchronous motors | | | | | |
| 15. Selection and driving ability of stepper motors | | | | | |
| 16. Able to select and debug servo motors | | | | | |
| 17. Can maintain the power supply and distribution system of the factory building | | | | | |
| 18. Able to install and adjust automated production lines | | | | | |
| 19. Can maintain industrial robots | | | | | |
| 20. Able to simulate robot workstations | | | | | |
| 21. Able to install and debug PLC control systems | | | | | |
| 22. Able to troubleshoot PLC control system faults | | | | | |
| 23. Proficient in operating equipment | | | | | |
| 24. Able to manage equipment | | | | | |
| 25. Able to design 3D drawings | | | | | |
| 26. Able to operate industrial robots | | | | | |
| 27. Able to use office software | | | | | |
| 28. Able to operate CNC lathes | | | | | |
| 29. Able to debug industrial networks | | | | | |
| 30. Able to apply machine vision | | | | | |

| Questions | Answers | | | | |
|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 |
| 31. Able to install and debug pneumatic components | | | | | |
| 32. Able to install and debug hydraulic components | | | | | |
| 33. Able to perform 3D reverse design | | | | | |
| 34. Proficient in using English | | | | | |
| 35. Able to organize technical data according to specifications | | | | | |
| 36. Able to learn new technologies | | | | | |

Section 3: Do you have any good suggestions to improve students' professional practical abilities

Thank you for your kind cooperation for completing the questionnaire!

Researcher

Mr.Ming Xin

**Questionnaire For Experts (Objective 1)**

**Assessment form IOC for Validity of Employers' Demand for Practical Abilities Questionnaire**

**Research Title:** Modern Practice Teaching Model for Students Majoring in Electrical Automation Technology

**Research Objectives:** 1. To study employers' practical skills requirements for electrical automation technology graduates.

**Assessor:** Professor Jiang Sizhong
**Position:** Electrical Automation Technology Program
**Workplace:** Guangxi Vocational and Technical College

**Directions**: Please assess the congruence between factors and questions by putting √ in the box according to the following criteria.

+1 if you think the question CAN measure the factor given

0 if you are NOT SURE the question can measure the factor given

-1 if you think the question CANNOT measure the factor given

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| **Part 1** | **Relevant Information of the Respondent** | | | | |
| No. 1 | Number of employees<br>☐ Less than 200<br>☐ 200-500<br>☐ 500-1000<br>☐ More than 1000 | | | | |
| No. 2 | The industry of the company<br>☐ agricultural products processing<br>☐ Aluminum processing industry<br>☐ Chemical industry<br>☐ manufacturing<br>☐ Less than 200<br>☐ food industry<br>☐ electronic industry | | | | |
| No. 3 | Company area<br>☐ Guangxi Province<br>☐ Pearl River Delta region<br>☐ Yangtze River Delta region<br>☐ Other regions | | | | |
| **Part 2** | **Questionnaire on employers' demand for practical abilities of students majoring in electrical automation** | | | | |
| No. 1 | Able to read and draw various electrical principles and circuit diagrams | | | | |
| No. 2 | Able to process parts | | | | |

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| No. 3 | Able to assemble and debug electronic circuits | | | | |
| No. 4 | Able to recognize and draw mechanical structure diagrams | | | | |
| No. 5 | Able to identify and detect commonly used electronic components | | | | |
| No. 6 | Able to operate CNC machine tools | | | | |
| No. 7 | Proficient in using commonly used instruments and meters | | | | |
| No. 8 | Proficient in using commonly used electrical tools | | | | |
| No. 9 | Able to design and analyze low-voltage electrical circuits | | | | |
| No. 10 | Able to install and debug low-voltage electrical circuits | | | | |
| No. 11 | Able to design C language programs | | | | |
| No. 12 | Able to program microcontrollers | | | | |
| No. 13 | Able to write PLC programs | | | | |
| No. 14 | Selection and driving capability of three-phase asynchronous motors | | | | |
| No. 15 | Selection and driving ability of stepper motors | | | | |
| No. 16 | Able to select and debug servo motors | | | | |

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| No. 17 | Can maintain the power supply and distribution system of the factory building | | | | |
| No. 18 | Able to install and adjust automated production lines | | | | |
| No. 19 | Can maintain industrial robots | | | | |
| No. 20 | Able to simulate robot workstations | | | | |
| No. 21 | Able to install and debug PLC control systems | | | | |
| No. 22 | Able to troubleshoot PLC control system faults | | | | |
| No. 23 | Proficient in operating equipment | | | | |
| No. 24 | Able to manage equipment | | | | |
| No. 25 | Able to design 3D drawings | | | | |
| No. 26 | Able to operate industrial robots | | | | |
| No. 27 | Able to use office software | | | | |
| No. 28 | Able to operate CNC lathes | | | | |
| No. 29 | Able to debug industrial networks | | | | |
| No. 30 | Able to apply machine vision | | | | |
| No. 31 | Able to install and debug pneumatic components | | | | |
| No. 32 | Able to install and debug hydraulic components | | | | |
| No. 33 | Able to perform 3D reverse design | | | | |

| Items | Contents | Assessment Results +1 0 -1 | Remarks |
|---|---|---|---|
| No. 34 | Proficient in using English | | |
| No. 35 | Able to organize technical data according to specifications | | |
| No. 36 | Able to learn new technologies | | |

| Items | Contents | Assessment Results +1 0 -1 | Remarks |
|---|---|---|---|
| **Part 3** | **suggestions** | | |
| No. 1 | Do you have any good suggestions to improve students' professional practical abilities | | |

Suggestions...................................................................................................................

Sign...............................................Assessor

Date........../................../............

**Conformity Assessment Form of Modern practice teaching model for electrical automation technology (Objective 2)**

Directions:

These questionnaires are the instruments for collecting data in 2nd phase of the research entitled “modern practice teaching model for students majoring in electrical automation technology” conducted by Ming Xin, a Ph.D. student in Digital Technology Management for Education at Bansomdejchaopraya Rajabhat University under the supervision of Assistant Professor Dr. Prapai Sridama,majoring advisor,Assistant Professor Dr.Kanakorn Sawangcharoen co-advisor.

This questionnaire is divided into 3 sections i.e.
Section 1: Basic information of experts
Section 2:Evaluation Form for Modern Practice Teaching Mode for Students majoring in Electrical Automation Technology.The questionnaire type is a closed ended question, which can only be answered by selecting from the provided numbers to the summary rating scale (5 scales).
The relevant information collected in this questionnaire is only for the research of the topic, and the researcher will keep all information of the respondents confidential.

Answer the questionnaire:

Section1 ： Basic information of experts

Directions:Please put √ into the ☐ according to your owm personal data.

1.Your identity

☐Enterprise Engineer

☐ Vocational school teachers

☐ Enterprise HR

☐ Vocational education experts

☐Teaching management personnel in vocational schools

2.Your professional title

☐ Primary Title

☐ Middle Title

☐ Vice-senior Title

☐ Senior Title

3.Your age

☐ Less than 30

☐ 30-40

☐ 40-50

☐ Over 50 years old

Section 2: Evaluation Form for Modern Practice Teaching Mode in Electrical Automation.

Directions: Please evaluate whether the teaching model of the modern practice system is qualified according to various content. Each question can only have one answer to choose from.

5 means EXCELLENT.

4 means GOOD.

3 means AVERAGE.

2 means PASS.

1 means FAIL.

Table 1 Questionnaire on Qualification Evaluation of Modern Practice Teaching Mode in Electrical Automation Majors by Experts

| **Questions** | **Answers** | | | | |
|---|---|---|---|---|---|
| | **5** | **4** | **3** | **2** | **1** |
| Curriculum Framework | | | | | |
| 1.Job analysis | | | | | |
| 2.Job ability requirements | | | | | |
| 3.Analysis of typical work tasks | | | | | |
| 4.Knowledge Point Organization | | | | | |
| 5.Curriculum system construction | | | | | |

| Questions | Answers | | | | |
|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 |
| 6.Design of assessment methods | | | | | |
| Curriculum | | | | | |
| 7.Curriculum Standards for Pre job Safety Production Training | | | | | |
| 8.Curriculum Standards for Electrical Diagram Recognition and Circuit Maintenance | | | | | |
| 9.Curriculum Standards for Mechanical Drawing and Sugar Making Equipment Management | | | | | |
| 10.Curriculum Standards for Electrical and Electronic Technology Practice | | | | | |
| 11.Curriculum Standards for Installation and commissioning of non-standard electromechanical products | | | | | |
| 12.Curriculum Standards for Motor Drive Technology | | | | | |
| 13.Curriculum Standards for PLC Engineering Training | | | | | |
| 14.Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | | | | | |
| 15.Curriculum Standards for Productive Training | | | | | |
| Planning for the construction of teaching resources | | | | | |
| 16.Teacher Team Building Plan | | | | | |
| 17.Curriculum resource construction plan | | | | | |
| 18.Training Environment Construction Plan | | | | | |

Thank you for your kind cooperation for completing the questionnaire!

Researcher

Mr.Ming Xin

**Questionnaire for experts (Objective 2)**

Assessment form IOC for Validity of Questionnaire on Qualification Evaluation of Modern Practice Teaching Mode in Electrical Automation Majors

**Research Title：** Modern Practice Teaching Model for Students Majoring in Electrical Automation Technology

**Research Objectives**: 2. To design a modern practice teaching model for students majoring in electrical automation technology in Guangxi Vocational and Technical College.

**Assessor:** Professor Jiang Sizhong
**Position:** Electrical Automation Technology Program
**Workplace:** Guangxi Vocational and Technical College

**Directions**: Please assess the congruence between factors and questions by putting √ in the box according to the following criteria.

+1 if you think the question CAN measure the factor given

0 if you are NOT SURE the question can measure the factor given

-1 if you think the question CANNOT measure the factor given

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
| --- | --- | --- | --- | --- | --- |
| **Section 1** | **Basic information of experts** | | | | |
| No. 1 | Your identity<br>☐Enterprise Engineer<br>☐ Vocational school teachers<br>☐ Enterprise HR<br>☐ Vocational education experts<br>☐Teaching management personnel in vocational schools | | | | |
| No. 2 | Your professional title<br>☐ Primary Title<br>☐ Middle Title<br>☐ Vice-senior Title<br>☐ Senior Title | | | | |
| No. 3 | Your age<br>☐ Less than 30<br>☐ 30-40<br>☐ 40-50<br>☐ Over 50 years old | | | | |
| **Section 2** | **Evaluation Form for Modern Practice Teaching Mode in Electrical Automation** | | | | |
| **Part 1** | **Curriculum Framework** | | | | |
| No. 1 | Job analysis | | | | |
| No. 2 | Job ability requirements | | | | |
| No. 3 | Analysis of typical work tasks | | | | |
| No. 4 | Knowledge Point Organization | | | | |
| No. 5 | Curriculum system construction | | | | |

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| **Part 2** | **Curriculum Design** | | | | |
| No. 6 | Design of assessment methods | | | | |
| No. 7 | Curriculum Standards for Pre job Safety Production Training | | | | |
| No. 8 | Curriculum Standards for Factory Power Distribution and Maintenance | | | | |
| No. 9 | Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | | | | |
| No. 10 | Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | | | | |
| No. 11 | Curriculum Standards for Installation and Maintenance of Vertical Warehouse | | | | |
| No. 12 | Curriculum Standards for Installation and commissioning of non-standard electromechanical products | | | | |
| No. 13 | Curriculum Standards for Motor Drive Technology | | | | |
| No. 14 | Curriculum Standards for Industrial Networking and Data Collection | | | | |
| No. 15 | Curriculum Standards for Productive Training | | | | |
| **Part** 3 | Planning for the construction of teaching resources | | | | |
| No. 16 | Teacher Team Building Plan | | | | |
| No. 17 | Curriculum resource construction plan | | | | |
| No. 18 | Training Environment Construction Plan | | | | |

Sign...............................................Assessor

Date........../................./............

## Lesson Plan (Objective 3)

A total of 20 students from Class 2 of the Electrical Automation major in the 2021 grade were selected as experimental samples, using a modern practice curriculum plan. 20 students from Class 1 of the Electrical Automation major in the 2021 grade were selected as the control group, using a traditional course plan.

**Table 1 2021 Electrical Automation Technology Major Course Setting and Teaching Schedule (Traditional)**

| Course category | | NO | Course Title | Semester | Hours | theory | practice | Semester/Hours 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Public basic courses | Basic quality courses | 1 | College Chinese | 3 | 48 | 42 | 6 | 48 | | | | | |
| | | 2 | Ancient Chinese History | 4 | 64 | 54 | 10 | 64 | | | | | |
| | | 3 | Modern Chinese History | 1 | 48 | 48 | 0 | 48 | | | | | |
| | | 4 | Career Planning and Entrepreneurship Guidance | 1 | 44 | 0 | 44 | 44 | | | | | |
| | | 5 | Military Courses and Admission Education for College Students | 4 | 148 | 36 | 112 | 148 | | | | | |
| | | 6 | Psychological Health Education for College Students | 2 | 32 | 24 | 8 | 32 | | | | | |
| | | 7 | Physical Education | 6 | 120 | 0 | 120 | 30 | 30 | 30 | 30 | | |
| | | 8 | Labor Education | 1 | 24 | 12 | 12 | | 24 | | | | |
| | | 9 | Foundation of Entrepreneurship for College Students | 2 | 40 | 0 | 40 | | | | | | |
| | | 10 | College English | 2 | 32 | 32 | 0 | | 32 | | | | |
| | | 11 | Professional English 1 | 2 | 32 | 32 | 0 | 32 | | | | | |
| | | 12 | Professional English 2 | 2 | 32 | 32 | 0 | | 32 | | | | |

**Table 1 (continued)**

| Course category | | NO | Course Title | Semester | Hours | theory | practice | Semester/Hours 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Professional Learning Area Courses | Professional basic courses | 1 | Applied mathematics for electrical engineering | 2 | 36 | 36 | | | 36 | | | | |
| | | 2 | Computer and network application technology | 3 | 50 | 40 | 10 | | 50 | | | | |
| | | 3 | Electrical engineering technology | 2.5 | 48 | 24 | 24 | | 48 | | | | |
| | | 4 | Mechanical drawing | 3 | 60 | 40 | 20 | | 60 | | | | |
| | | 5 | Parts clamp processing | 1.5 | 28 | 8 | 20 | | 28 | | | | |
| | | 6 | AutoCAD | 2 | 40 | 20 | 20 | | 40 | | | | |
| | Module 1 Course | 7 | Electronic technology | 3 | 54 | 44 | 10 | | | 54 | | | |
| | | 8 | Application of power supply and distribution technology in factories | 3 | 54 | 30 | 24 | | | 54 | | | |
| | | 9 | Equipment management and preventive maintenance | 2 | 36 | 26 | 10 | | | 36 | | | |
| | | 10 | Electrical engineering drawing | 2 | 36 | 26 | 10 | | | 36 | | | |
| | | 11 | Hydraulic and pneumatic technology | 2.5 | 48 | 20 | 28 | | | 44 | | | |

**Table 1 (continued)**

| Course category | NO | Course Title | Semester | Hours | theory | practice | Semester/Hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Module 2 Course | 12 | Electrical circuit analysis and installation and debugging | 4 | 72 | 52 | 20 | | | 72 | | | |
| | 13 | Automated production line installation and debugging | 4 | 72 | 62 | 10 | | | 72 | | | |
| Module 3 Course | 14 | Microcontroller application technology | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 15 | C language programming basics | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 16 | Detection and process control technology | 2 | 44 | 30 | 14 | | | | 44 | | |
| | 17 | Configuration and touch screen control technology | 2 | 36 | 20 | 16 | | | | 36 | | |
| | 18 | PLC control system installation and programming | 4 | 72 | 52 | 20 | | | | 72 | | |
| | 19 | Machine tool electrical circuit maintenance | 2.5 | 44 | 30 | 14 | | | | 44 | | |

**Table 1 (continued)**

| Course category | | NO | Course Title | Semester | Hours | theory | practice | Semester/Hours 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 20 | Industrial robot technology application | 4 | 72 | 62 | 10 | | | | 72 | | |
| | Professional practice module | 21 | On-the-job internship | 24 | 576 | | 576 | | | | | | 576 |
| | | 22 | Graduation project (thesis) | 6 | 120 | | 120 | | | | | 120 | |
| Professional Elective | Elective modules | 1 | Motion control technology | 4 | 72 | 62 | 10 | | | | | 72 | |
| | | 2 | Industrial robot application and programming | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | 3 | Machine vision technology | 2 | 36 | 26 | 10 | | | | | 36 | |
| | | 4 | Industrial network technology | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | 5 | DCS system installation, commissioning and operation and maintenance | 3 | 54 | 34 | 20 | | | | | 54 | |
| | | | Total | 130 | 2640 | 1212 | 1428 | 446 | 420 | 398 | 406 | 390 | 576 |

**Table 2 2021 Electrical Automation Technology Major Course Setting and Teaching Schedule (Modern Practice System)**

| Course category | | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| Public basic courses | Basic quality courses | 1 | College Chinese | 3 | 48 | 42 | 6 | 48 | | | | | |
| | | 2 | Ancient Chinese History | 4 | 64 | 54 | 10 | 64 | | | | | |
| | | 3 | Modern Chinese History | 1 | 48 | 48 | 0 | 48 | | | | | |
| | | 4 | Career Planning and Entrepreneurship Guidance | 1 | 44 | 0 | 44 | 44 | | | | | |
| | | 5 | Military Courses and Entrance Education for College Students | 4 | 148 | 36 | 112 | 148 | | | | | |
| | | 6 | Psychological Health Education for College Students | 2 | 32 | 24 | 8 | 32 | | | | | |
| | | 7 | Physical Education | 6 | 120 | 0 | 120 | 30 | 30 | 30 | 30 | | |
| | | 8 | Labor Education | 1 | 24 | 12 | 12 | | 24 | | | | |
| | | 9 | Foundation of Entrepreneurship for College Students | 2 | 40 | 0 | 40 | | 40 | | | | |
| | | 10 | College English | 2 | 32 | 32 | 0 | | 32 | | | | |

**Table 2 (continued)**

| Course category | | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| Professional Learning Area Courses | Professional basic courses | 11 | Professional English 1 | 2 | 32 | 32 | 0 | 32 | | | | | |
| | | 12 | Professional English 2 | 2 | 32 | 32 | 0 | | 32 | | | | |
| | | 1 | Applied Mathematics for Electrical Majors | 2 | 36 | 36 | | | 36 | | | | |
| | | 2 | Computer and Network Application Technology | 3 | 50 | 40 | 10 | | 50 | | | | |
| | | 3 | Electrical Engineering Technology | 2.5 | 48 | 24 | 24 | | 48 | | | | |
| | | 4 | Mechanical Drawing | 3 | 60 | 40 | 20 | | 60 | | | | |
| | | 5 | Parts Claw Processing | 1.5 | 28 | 8 | 20 | | 28 | | | | |
| | | 6 | AutoCAD | 2 | 40 | 20 | 20 | | 40 | | | | |
| | | 7 | Electronic Technology | 3 | 54 | 44 | 10 | | | 54 | | | |
| | Module 1 Course | 8 | Application of Factory Power Supply and Distribution Technology | 3 | 54 | 30 | 24 | | | 54 | | | |

**Table 2 (continued)**

| Course category | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | 9 | Equipment Management and Preventive Maintenance | 2 | 36 | 26 | 10 | | | 36 | | | |
| | 10 | Electrical Engineering Drawing | 2 | 36 | 26 | 10 | | | 36 | | | |
| | 11 | Hydraulic and Pneumatic Technology | 2.5 | 48 | 20 | 28 | | | 44 | | | |
| | 12 | Electrical Circuit Analysis and Installation and Debugging | 4 | 72 | 52 | 20 | | | 72 | | | |
| Module 2 Course | 13 | Automated Production Line Installation and Debugging | 4 | 72 | 62 | 10 | | | 72 | | | |
| | 14 | Microcontroller Application Technology | 3 | 54 | 44 | 10 | | | | 54 | | |
| | 15 | C Language Programming Basics | 3 | 54 | 44 | 10 | | | | 54 | | |

**Table 2 (continued)**

| Course category | | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | Module 3 Course | 16 | Detection and Process Control Technology | 2 | 44 | 30 | 14 | | | | 44 | | |
| | | 17 | Configuration and Touch Screen Control Technology | 2 | 36 | 20 | 16 | | | | 36 | | |
| | | 18 | PLC Control System Installation and Programming | 4 | 72 | 52 | 20 | | | | 72 | | |
| | | 19 | Machine Tool Electrical Circuit Maintenance | 2.5 | 44 | 30 | 14 | | | | 44 | | |
| | | 20 | Industrial Robot Technology Application | 4 | 72 | 62 | 10 | | | | 72 | | |
| Practical skills improvement area | Modern practice courses | 1 | Pre-job Safety Production Training | 2 | 36 | 26 | 10 | | | | | 36 | |
| | | 2 | Electrical Drawing Recognition and Circuit Inspection and Repair | 4 | 72 | 10 | 62 | | | | | 72 | |

**Table 2 (continued)**

| Course category | NO | Course Title | Semester | Semester/Hours | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Hours | theory | practice | 1 | 2 | 3 | 4 | 5 | 6 |
| | 3 | Mechanical Drawing and Sugar Making Equipment Management | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 4 | Practical Operation of Electrical and Electronic Technology | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 5 | Installation and Debugging of Non-standard Electromechanical Products | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 6 | Motor Drive Technology | 4 | 72 | 10 | 62 | | | | | 72 | |
| | 7 | PLC Engineering Training | 4 | 72 | 10 | 62 | | | | | | 72 |
| | 8 | Smart Manufacturing Production Line Maintenance | 4 | 72 | 10 | 62 | | | | | | 72 |
| | 9 | Productive Training | 30 | 576 | 0 | 576 | | | | | | 576 |
| | Total | | 145 | 2790 | 1118 | 1672 | 446 | 420 | 398 | 406 | 396 | 720 |

**Questionnaire for experts (Objective 3)**

Assessment form IOC for Validity of Course Plan of Modern Practice Teaching Mode in Electrical Automation Majors

**Research Title** **:** Modern Practice Teaching Model for Students Majoring in Electrical Automation Technology

**Research Objectives**: 3.To evaluate the modern practice teaching model of electrical automation technology major.

**Assessor:** Professor Jiang Sizhong
**Position:** Electrical Automation Technology Program
**Workplace:** Guangxi Vocational and Technical College

**Directions**: Please assess the congruence between factors and questions by putting √ in the box according to the following criteria.

+1 if you think the content CAN be useful for research objectives

0 if you are NOT SURE the content can be useful for research objectives

-1 if you think the content CANNOT be useful for research objectives

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| **Section 1** | **Curriculum Setting and Teaching Progress Table for Electrical Automation Technology Major in 2021(Modern Practice)** | | | | |
| No. 1 | Applied Mathematics in Electrical Engineering | | | | |
| No. 2 | Computer and Network Application Technology | | | | |
| No. 3 | Electrical technology | | | | |
| No. 4 | Mechanical Drawing | | | | |
| No. 5 | Part Processing | | | | |
| No. 6 | AutoCAD | | | | |
| No. 7 | Electronic Technique | | | | |
| No.8 | Electrical Circuit Analysis and Installation Debugging | | | | |
| No.9 | Fundamentals of C Language Programming | | | | |
| No. 10 | Microcontroller Application Technology | | | | |
| No. 11 | Detection and Process Control Technology | | | | |
| No. 12 | Installation and Programming of PLC Control System | | | | |
| No. 13 | Machine Tool Electrical Circuit Maintenance | | | | |
| No. 14 | Application of Industrial Robot Technology | | | | |
| No. 15 | Electrical Engineering Drawing | | | | |
| No. 16 | Pre job Safety Production Training | | | | |
| No. 17 | Electrical Diagram Recognition and Circuit Maintenance | | | | |
| No. 18 | Mechanical Drawing and Sugar Making Equipment Management | | | | |
| No. 19 | Electrical and Electronic Technology Practice | | | | |
| No. 20 | Installation and commissioning of non-standard electromechanical products | | | | |

| Items | Contents | Assessment Results +1 | 0 | -1 | Remarks |
|---|---|---|---|---|---|
| No. 21 | Motor Drive Technology | | | | |
| No. 22 | PLC Engineering Training | | | | |
| No. 23 | Intelligent Manufacturing Production Line Maintenance | | | | |
| No. 24 | Productive Training | | | | |
| **Section 2** | **Curriculum Setting and Teaching Progress Table for Electrical Automation Technology Major in 2021 (Traditional Method)** | | | | |
| No. 1 | Applied Mathematics in Electrical Engineering | | | | |
| No. 2 | Computer and Network Application Technology | | | | |
| No. 3 | Electrical technology | | | | |
| No. 4 | Mechanical Drawing | | | | |
| No. 5 | Part Processing | | | | |
| No. 6 | Auto CAD | | | | |
| No. 7 | Electronic Technique | | | | |
| No.8 | Factory Power Supply and Distribution Technology | | | | |
| No.9 | Equipment Management and Preventive Maintenance | | | | |
| No. 10 | Equipment Management and Preventive Maintenance | | | | |
| No. 11 | Hydraulic and Pneumatic Technology | | | | |
| No. 12 | Electrical Circuit Analysis and Installation Debugging | | | | |
| No. 13 | Installation and Debugging of Automated Production Lines | | | | |
| No. 14 | Microcontroller Application Technology | | | | |
| No. 15 | Fundamentals of C Language Programming | | | | |

| Items | Contents | Assessment Results | | | Remarks |
|---|---|---|---|---|---|
| | | +1 | 0 | -1 | |
| No. 16 | Testing and Process Control Technology | | | | |
| No. 17 | Configuration and Touch Screen Control Technology | | | | |
| No. 18 | Installation and Programming of PLC Control System | | | | |
| No. 19 | Machine Tool Electrical Circuit Maintenance | | | | |
| No. 20 | Application of Industrial Robot Technology | | | | |
| No. 21 | On the Job Internship | | | | |
| No. 22 | Graduation Thesis | | | | |

Suggestions.............................................................................................................. ..

.................................................................................................................................. .............

Sign...............................................Assessor

Date........../................../.............

**Evaluation Form for Practical Ability of Electrical Automation Majors (Objective 3)**

**2021 Electrical Automation Technology Professional Practical Skills Assessment Plan and Test Paper Database**

**1. Purpose of Assessment**

This assessment plan aims to comprehensively evaluate the professional practice ability of students majoring in electrical automation technology, and ensure that students have the necessary theoretical knowledge and practical skills to adapt to the needs of future jobs.

**2. Assessment Target**

Students majoring in electrical automation technology.

**3. Assessment Content**

The assessment content covers the following 10 abilities:

Electrical principles and electrical circuit diagram reading and drawing ability.

Electronic circuit assembly and debugging ability.

Mechanical structure diagram reading and drawing ability.

Electronic component identification and detection ability.

Common instrumentation use ability.

Electrical tool use ability.

Low-voltage electrical circuit design and analysis ability.

Low-voltage electrical circuit installation and debugging ability.

PLC control system installation and debugging ability.

PLC control system fault troubleshooting ability.

**4. Assessment Method**

Assessment form: Online answering on the Chaoxing Learning website.

Question bank composition: A question bank is set up for each ability point, and the question bank contains 10 related questions.

Question extraction: During the assessment, 1 question is randomly selected for each ability point, and a total of 10 questions are selected. Each question is 10 points, for a total of 100 points.

**5. Scoring points**

Theoretical knowledge: the degree of students' mastery of professional theories.

Operational skills: the skill level demonstrated by students in actual operations.

Problem solving: the ability of students to analyze and solve problems when faced with them.

Innovation ability: the innovative thinking demonstrated by students in the process of answering questions.

**Practical Ability Test Question Bank for Electrical Automation Technology**

**I. Electrical Principles and Reading and Drawing of Electrical Circuit Diagrams**

1. Describe how to read a typical three-phase motor control circuit diagram.
2. Explain the symbol representation method in the electrical schematic diagram.
3. Draw a simple household circuit wiring diagram and mark the main components.
4. Explain how to use AutoCAD software to draw an electrical schematic diagram.
5. Describe how to wire the actual circuit according to the electrical schematic diagram.
6. Explain how to represent grounding and protective grounding in the electrical schematic diagram.
7. Draw a motor starting circuit diagram with overload protection.
8. Explain how to identify different types of relays in the electrical schematic diagram.
9. Describe how to perform fault diagnosis based on the electrical schematic diagram.
10. Draw a single-phase motor control circuit diagram with automatic restart function.

**II. Electronic Circuit Assembly and Debugging**

1. Describe how to assemble circuit boards using welding technology.

2. Explain anti-static measures in circuit assembly.
3. Describe how to debug oscillation circuits using an oscilloscope.
4. Explain how to measure signal integrity in a circuit.
5. Describe how to use a multimeter to detect shorts and breaks in a circuit.
6. Explain how to adjust the bias voltage in a circuit to optimize performance.
7. Explain how to use a frequency meter to measure the oscillation frequency of a circuit.
8. Describe how to use a logic analyzer to debug a digital circuit.
9. Explain how to use a power analyzer to debug a power circuit.
10. Describe how to use a temperature control circuit for temperature compensation.

**III. Reading and drawing mechanical structure drawings**

1. Describe how to read the three views of a mechanical part.
2. Explain the dimensioning method in mechanical drawings.
3. Draw a simple mechanical arm structure drawing.
4. Explain how to use SolidWorks software to draw a mechanical structure drawing.
5. Describe how to process parts based on the mechanical structure drawing.
6. Explain the tolerance marking in mechanical drawings and its importance.
7. Draw a mechanical shaft structure drawing with bearings.
8. Explain how to identify assembly marks in mechanical drawings.
9. Describe how to assemble parts according to mechanical structure drawings.
10. Explain welding symbols in mechanical drawings and their applications.

**IV. Identification and detection of electronic components**

1. Describe how to identify different types of resistors.
2. Explain how to use a multimeter to detect the capacitance of a capacitor.
3. Describe how to identify and detect the polarity of a diode.
4. Explain how to use an oscilloscope to detect the amplification characteristics of a transistor.
5. Explain how to identify the pin function of an integrated circuit.
6. Describe how to detect the inductance of an inductor.
7. Explain how to identify and detect an optocoupler.

8. Describe how to use an LCR meter to measure the parameters of electronic components.
9. Explain how to identify and detect piezoelectric elements.
10. Explain how to use a thermal imager to detect hot spots in a circuit.

**V. Use of common instruments and meters**

1. Describe how to use an oscilloscope to measure the frequency and amplitude of a signal.
2. Explain how to use a multimeter to measure resistance, current, and voltage.
3. Describe how to use a signal generator to generate sine, square, and triangle waves.
4. Explain how to use a frequency meter to measure the frequency of a signal.
5. Describe how to use a power meter to measure the power consumption of a circuit.
6. Explain how to use a logic analyzer to capture and analyze digital signals.
7. Describe how to use a thermometer to measure ambient temperature.
8. Explain how to use a manometer to measure pressure.
9. Describe how to use a current clamp to measure AC current.
10. Explain how to use an insulation resistance meter to measure insulation resistance.

**VI. Use of electrical tools**

1. Describe how to safely use a soldering iron for soldering.
2. Explain how to use a wire stripper to strip a cable.
3. Describe how to use a crimping pliers to crimp cable connectors.
4. Explain how to use a screwdriver to install and remove electrical components.
5. Describe how to use an electrician's knife to cut cables.
6. Explain how to use insulating tape to insulate cables.
7. Describe how to use terminal blocks to make electrical connections.
8. Explain how to use a multimeter to test a circuit.
9. Describe how to use an insulation resistance meter to test insulation.
10. Explain how to use a ground resistance tester to test a grounding system.

**VII. Low-voltage electrical circuit design and analysis**

1. Describe how to design a simple household electrical circuit.
2. Explain how to analyze the power consumption of a circuit.
3. Describe how to design a circuit with overload protection.
4. Explain how to analyze the efficiency of a circuit.
5. Describe how to design an energy-saving lighting circuit.
6. Explain how to analyze the thermal effects of a circuit.
7. Describe how to design a circuit with short-circuit protection.
8. Explain how to analyze the electromagnetic compatibility of a circuit.
9. Describe how to design a circuit with leakage protection.
10. Explain how to analyze the safety of a circuit.

**VIII. Low-voltage electrical line installation and commissioning**

1. Describe how to lay cables.
2. Explain how to fix cables.
3. Describe how to ground electrical equipment.
4. Explain how to connect electrical circuits.
5. Describe how to install terminal blocks.
6. Explain how to insulate cables.
7. Describe how to perform insulation tests on electrical circuits.
8. Explain how to perform ground resistance tests on electrical circuits.
9. Describe how to perform load tests on electrical circuits.
10. Explain how to maintain and inspect electrical circuits.

**IX. Installation and debugging of PLC control systems**

1. Describe how to install a PLC control system.
2. Explain how to configure the hardware of a PLC system.
3. Describe how to use PLC programming software to write control programs.
4. Explain how to download and upload PLC programs.
5. Describe how to debug a PLC system.
6. Explain how to use the diagnostic function of a PLC.
7. Describe how to optimize a PLC program.
8. Explain how to simulate faults in a PLC system.

9. Describe how to maintain a PLC system.

10. Explain how to upgrade and expand a PLC system.

**X. Troubleshooting of PLC control systems**

1. Describe how to use the diagnostic function of the PLC to detect faults.
2. Explain common PLC hardware faults and their causes.
3. Describe how to use the online monitoring function of the PLC for fault analysis.
4. Explain how to diagnose PLC program faults.
5. Describe how to troubleshoot PLC input/output modules.
6. Explain how to troubleshoot PLC power modules.
7. Describe how to troubleshoot PLC communication modules.
8. Explain how to troubleshoot PLC internal logic.
9. Describe how to troubleshoot PLC external connections.
10. Explain how to develop a troubleshooting process for a PLC system.

**Assessment form IOC for Validity of Pre test and post test using Practical Ability Test Question Bank**

**Research Title:** Modern Practice Teaching Model for Students Majoring in Electrical Automation Technology

**Research Objectives**: 3. To evaluate the modern practice teaching (MAT) model of electrical automation technology major.

**Assessor:** Professor Jiang Sizhong
**Position:** Electrical Automation Technology Program
**Workplace:** Guangxi Vocational and Technical College

**Directions**: Please assess the congruence between factors and questions by putting √ in the box according to the following criteria.

+1 if you think the content CAN be useful for research objectives
0 if you are NOT SURE the content can be useful for research objectives
-1 if you think the content CANNOT be useful for research objectives

| Items | Contents | Assessment Results | | | Remarks |
|---|---|---|---|---|---|
| | | +1 | 0 | -1 | |
| **Section 1** | **Pre test** | | | | |
| No. 1 | Electrical principles and reading and drawing of electrical circuit diagrams | | | | |
| No. 2 | Assembly and debugging of electronic circuits | | | | |
| No. 3 | Reading and drawing of mechanical structure diagrams | | | | |
| No. 4 | Identification and detection of electronic components | | | | |
| No. 5 | Use of common instruments and meters | | | | |
| No. 6 | Use of electrical tools | | | | |
| No. 7 | Design and analysis of low-voltage electrical circuits | | | | |
| No. 8 | Installation and debugging of low-voltage electrical circuits | | | | |
| No. 9 | Installation and debugging of PLC control systems | | | | |
| No. 10 | Troubleshooting of PLC control systems | | | | |
| **Section 2** | **Post test** | | | | |
| No. 1 | Electrical principles and reading and drawing of electrical circuit diagrams | | | | |
| No. 2 | Assembly and debugging of electronic circuits | | | | |
| No. 3 | Reading and drawing of mechanical structure diagrams | | | | |
| No. 4 | Identification and detection of electronic components | | | | |
| No. 5 | Use of common instruments and meters | | | | |
| No. 6 | Use of electrical tools | | | | |

| Items | Contents | Assessment Results | | | Remarks |
|---|---|---|---|---|---|
| | | +1 | 0 | -1 | |
| No. 7 | Design and analysis of low-voltage electrical circuits | | | | |
| No. 8 | Installation and debugging of low-voltage electrical circuits | | | | |
| No. 9 | Installation and debugging of PLC control systems | | | | |
| No. 10 | Troubleshooting of PLC control systems | | | | |

# Appendix D
# The Results of the Quality Analysis of Research Instruments

**Evaluation form for evaluate compliance**

Subject

Evaluate the elements of Questionnaire on practical ability of students majoring in electrical automation technology

| Items | Contents | Expert opinion 1 | 2 | 3 | 4 | 5 | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| **Part 1** | **Relevant Information of the Respondent** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Number of employees<br>Less than 200<br>200-500<br>500-1000<br>More than 1000 | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | The industry of the company<br>agricultural products processing<br>Aluminum processing industry<br>Chemical industry<br>manufacturing<br>Less than 200<br>food industry<br>electronic industry | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 3 | Company area<br>Guangxi Province<br>Pearl River Delta region<br>Yangtze River Delta region<br>Other regions | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

| Items | Contents | Expert opinion 1 | 2 | 3 | 4 | 5 | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| **Part 2** | **Questionnaire on employers' demand for practical abilities of students majoring in electrical automation** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Able to read and draw various electrical principles and circuit diagrams | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Able to process parts | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Able to assemble and debug electronic circuits | 1 | 1 | 1 | 1 | 0 | 0.8 | Valid |
| No. 4 | Able to recognize and draw mechanical structure diagrams | 0 | 1 | 1 | 1 | 1 | 0.8 | Valid |
| No. 5 | Able to identify and detect commonly used electronic components | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | Able to operate CNC machine tools | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 7 | Proficient in using commonly used instruments and meters | 0 | 1 | 1 | 1 | 1 | 0.8 | Valid |
| No. 8 | Proficient in using commonly used electrical tools | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 9 | Able to design and analyze low-voltage electrical circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 10 | Able to install and debug low-voltage electrical circuits | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 11 | Able to design C language programs | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 12 | Able to program microcontrollers | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 13 | Able to write PLC programs | 1 | 0 | 1 | 1 | 1 | 1 | Valid |
| No. 14 | Selection and driving capability of three-phase asynchronous motors | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| No. 15 | Selection and driving ability of stepper motors | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 16 | Able to select and debug servo motors | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 17 | Can maintain the power supply and distribution system of the factory building | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |
| No. 18 | Able to install and adjust automated production lines | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 19 | Can maintain industrial robots | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 20 | Able to simulate robot workstations | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 21 | Able to install and debug PLC control systems | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 22 | Able to troubleshoot PLC control system faults | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 23 | Proficient in operating equipment | 0 | 1 | 1 | 1 | 1 | 0.8 | Valid |
| No. 24 | Able to manage equipment | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 25 | Able to design 3D drawings | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 26 | Able to operate industrial robots | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 27 | Able to use office software | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 28 | Able to operate CNC lathes | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

**Table (continued)**

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| No. 29 | Able to debug industrial networks | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 30 | Able to apply machine vision | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 31 | Able to install and debug pneumatic components | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 32 | Able to install and debug hydraulic components | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 33 | Able to perform 3D reverse design | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 34 | Proficient in using English | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 35 | Able to organize technical data according to specifications | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 36 | Able to learn new technologies | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| **Part 3** | **suggestions** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Do you have any good suggestions to improve students' professional practical abilities | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

**Evaluation form for evaluate compliance**

Subject

Evaluate the elements of Questionnaire on Qualification Evaluation of Modern Practice Teaching Mode in Electrical Automation Majors

| Items | Contents | Expert opinion 1 | 2 | 3 | 4 | 5 | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| **Section 1** | **Basic information of experts** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Your identity<br>¨Enterprise Engineer<br>¨ Vocational school teachers<br>¨ Enterprise HR<br>¨ Vocational education experts<br>¨Teaching management personnel in vocational schools | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Your professional title<br>¨ Primary Title<br>¨ Middle Title<br>¨ Vice-senior Title<br>¨ Senior Title | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Your age<br>¨ Less than 30<br>¨ 30-40<br>¨ 40-50<br>¨ Over 50 years old | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| **Section 2** | **Evaluation Form for Modern Practice Teaching Mode in Electrical Automation** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| **Part 1** | **Curriculum Framework** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Job analysis | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Job ability requirements | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 3 | Analysis of typical work tasks | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

| Items | Contents | Expert opinion | | | | | IOC | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | value | |
| No. 4 | Knowledge Point Organization | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 5 | Curriculum system construction | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | Design of assessment methods | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| **Part 2** | **Curriculum Design** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 7 | Curriculum Standards for Pre job Safety Production Training | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 8 | Curriculum Standards for Factory Power Distribution and Maintenance | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 9 | Curriculum Standards for Management of Mechanical and Electrical Equipment for Sugar Production | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 10 | Curriculum Standards for Intelligent Manufacturing Production Line Maintenance | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |
| No. 11 | Curriculum Standards for Installation and Maintenance of Vertical Warehouse | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 12 | Curriculum Standards for Installation and commissioning of non-standard electromechanical products | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 13 | Curriculum Standards for Motor Drive Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 14 | Curriculum Standards for Industrial Networking and Data Collection | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 15 | Curriculum Standards for Productive Training | 1 | 1 | 0 | 1 | 1 | 1 | Valid |

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| **Part 3** | Planning for the construction of teaching resources | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 16 | Teacher Team Building Plan | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 17 | Curriculum resource construction plan | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 18 | Training Environment Construction Plan | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

**Evaluation form for evaluate compliance**

Subject

Evaluate the elements of Validity of Course Plan of Modern Practice Teaching Mode in Electrical Automation Majors

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| **Section 1** | **Curriculum Setting and Teaching Progress Table for Electrical Automation Technology Major in 2021(Modern Practice)** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Applied Mathematics in Electrical Engineering | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Computer and Network Application Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Electrical technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 4 | Mechanical Drawing | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 5 | Part Processing | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | AutoCAD | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |
| No. 7 | Electronic Technique | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No.8 | Electrical Circuit Analysis and Installation Debugging | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No.9 | Fundamentals of C Language Programming | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 10 | Microcontroller Application Technology | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 11 | Detection and Process Control Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 12 | Installation and Programming of PLC Control System | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 13 | Machine Tool Electrical Circuit Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| No. 14 | Application of Industrial Robot Technology | 1 | 1 | 1 | 1 | 0 | 0.8 | Valid |
| No. 15 | Electrical Engineering Drawing | 0 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 16 | Pre job Safety Production Training | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 17 | Electrical Diagram Recognition and Circuit Maintenance | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |
| No. 18 | Mechanical Drawing and Sugar Making Equipment Management | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 19 | Electrical and Electronic Technology Practice | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 20 | Installation and commissioning of non-standard electromechanical products | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 21 | Motor Drive Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 22 | PLC Engineering Training | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 23 | Intelligent Manufacturing Production Line Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 24 | Productive Training | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| **Section 2** | **Curriculum Setting and Teaching Progress Table for Electrical Automation Technology Major in 2021 (Traditional Method)** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Applied Mathematics in Electrical Engineering | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Computer and Network Application Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Electrical technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 4 | Mechanical Drawing | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 5 | Part Processing | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | Auto CAD | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |

| Items | Contents | Expert opinion 1 | 2 | 3 | 4 | 5 | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| No. 7 | Electronic Technique | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No.8 | Factory Power Supply and Distribution Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No.9 | Equipment Management and Preventive Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 10 | Equipment Management and Preventive Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 11 | Hydraulic and Pneumatic Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 12 | Electrical Circuit Analysis and Installation Debugging | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 13 | Installation and Debugging of Automated Production Lines | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 14 | Microcontroller Application Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 15 | Fundamentals of C Language Programming | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 16 | Testing and Process Control Technology | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 17 | Configuration and Touch Screen Control Technology | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 18 | Installation and Programming of PLC Control System | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 19 | Machine Tool Electrical Circuit Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 20 | Application of Industrial Robot Technology | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |
| No. 21 | On the Job Internship | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 22 | Graduation Thesis | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

**Evaluation form for evaluate compliance**

Subject

Evaluate the elements of Validity of Pre test and post test using Practical Ability Test Question Bank

| Items | Contents | Expert opinion | | | | | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| **Section 1** | **Pre test** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Electrical principles and reading and drawing of electrical circuit diagrams | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Assembly and debugging of electronic circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Reading and drawing of mechanical structure diagrams | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 4 | Identification and detection of electronic components | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 5 | Use of common instruments and meters | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | Use of electrical tools | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 7 | Design and analysis of low-voltage electrical circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 8 | Installation and debugging of low-voltage electrical circuits | 1 | 0 | 1 | 1 | 1 | 0.8 | Valid |
| No. 9 | Installation and debugging of PLC control systems | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 10 | Troubleshooting of PLC control systems | 1 | 1 | 1 | 0 | 1 | 0.8 | Valid |

| Items | Contents | Expert opinion 1 | 2 | 3 | 4 | 5 | IOC value | Results |
|---|---|---|---|---|---|---|---|---|
| **Section 2** | **Post test** | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 1 | Electrical principles and reading and drawing of electrical circuit diagrams | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 2 | Assembly and debugging of electronic circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 3 | Reading and drawing of mechanical structure diagrams | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 4 | Identification and detection of electronic components | 1 | 1 | 0 | 1 | 1 | 0.8 | Valid |
| No. 5 | Use of common instruments and meters | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 6 | Use of electrical tools | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 7 | Design and analysis of low-voltage electrical circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 8 | Installation and debugging of low-voltage electrical circuits | 1 | 1 | 1 | 1 | 1 | 1 | Valid |
| No. 9 | Installation and debugging of PLC control systems | 0 | 1 | 1 | 1 | 1 | 0.8 | Valid |
| No. 10 | Troubleshooting of PLC control systems | 1 | 1 | 1 | 1 | 1 | 1 | Valid |

# Appendix E

# Certificate of English

BANSOMDEJCHAOPRAYA
RAJABHAT UNIVERSITY

This is to certify that

***Mr. Ming Xin***

Achieved BSRU English Proficiency Test (BSRU-TEP) level

**C2**

Given on 22nd August 2021

(Assistant Professor Dr Kulsirin Aphiratvoradej)

Director

# Appendix F

# The Document for Accept Research

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No. IJSASR.230 Date: 20 July 2024

**Acceptance Letter**

Dear: **Ming Xin, Prapai Sridama, Piyanan Issaravit, and Kanakorn Sawangcharoen**

Paper Title: **Design of Modern Apprenticeship Teaching Mode for Students Majoring in Electrical Automation Technology**

This is to enlighten you that the above manuscript was reviewed and appraised by three different institute reviewer members of the **International Journal of Sociologies and Anthropologies Science Reviews (online)** [IJSASR], Old ISSN 2774-0366 (Online): New ISSN 2985-2730 (Online), indexed by **Thai Journal Citation Index Centre (TCI) Tier 2, DOI Crossref Member, and ResearchGate**. It is acceptable for publication in the IJSASR, which will be available in Volume 5 Issue 1 (January-February 2025) at https://so07.tci-thaijo.org/index.php/IJSASR/about

Sincerely

Asst. Prof. Dr. Sanya Kenaphoom
**Editor-In-Chief**

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# Research Profile

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