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Reform of the "Fundamentals and Skills of Electronic Technology" Course Based on the Vocational Education Eualification Framework

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Abstract: *The course "Fundamentals and Skills of Electronic Technology" is a core course for students majoring in electronic information. However, the development of its teaching syllabus faces three main issues. Firstly, the methods for students to acquire knowledge and the requirements for processing information are not clearly defined. Secondly, the working process requirements under standardized criteria are not well-defined, lacking explicit demands for students' information processing abilities, language communication skills, and mathematical logic operations. Lastly, there is a lack of explicit requirements for students' autonomy, responsibility, and creativity. To address these challenges, curriculum reform based on the vocational education qualification framework is proposed, which provides more specific requirements for setting teaching objectives. For instance, in the digital section of the course, a specific application scenario involving the design of combinational logic circuits is introduced. This scenario focuses on creating a calling circuit that prioritizes the care of critically ill patients in hospitals. Students are guided to analyze and design circuits and utilize LabVIEW software for circuit simulation. Through this approach, students' comprehensive abilities are enhanced, and they are better equipped to become highly skilled and qualified professionals for enterprises.*

Keywords: *Vocational education qualification framework, "Fundamentals and Skills of Electronic Technology", LabVIEW software, Design of combinational logic circuits*

1. Introduction

The vocational education qualification framework refers to an institutionalized qualification system that is outcome-oriented and based on a series of qualification levels and criteria for various levels and types of academic degrees, vocational qualification certificates, and skill level certificates. It is of great significance for promoting the modernization of education, building a lifelong learning society, and promoting the integration of educational systems.

The construction of national qualification frameworks began to emerge in the late 1980s and 1990s, with countries such as Australia, India, Germany, and the United Kingdom gradually establishing and operating their national qualification frameworks. After nearly 20 years of development, these countries have formed relatively mature national qualification framework systems. With the support of national policies, there is increasing importance placed on vocational education systems and the construction of lifelong learning societies. The "Implementation Plan for National Vocational Education Reform" (referred to as "20 Measures for Vocational Education") issued by the State Council in 2019 mentioned the need to improve the national vocational education system, promote the construction of qualification frameworks, and explore the mutual recognition and linkage of academic degree certificates and vocational skill level certificates. The 20th National Congress of the Communist Party of China proposed the need to coordinate and innovate vocational education, higher education, and continuing education, and promote the integration of vocational and general education[1-2].

Although there is currently no national-level qualification framework in place, there have been pilot practices based on foreign experiences at the local level. For example, the Education Bureau of the Hong Kong Special Administrative Region introduced the Qualifications Framework and related quality assurance mechanisms in 2004. In 2017, Guangdong Province issued the Guangdong Lifelong Education Qualifications Framework (Guangdong Qualifications Framework) in the form of local standards. The

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Hong Kong Qualifications Framework has already established links with the European Union and New Zealand, while the design of the Guangdong Qualifications Framework can also achieve a more seamless alignment with regional frameworks such as the European Union.

In other words, the vocational education qualification framework is an education and training framework based on vocational competencies. It describes the skills, knowledge, abilities, and qualities required for specific occupations or industries, providing students and job seekers with clear learning paths and development directions. In Xu Guoqing's study on practice-oriented vocational education curriculum, it concludes that "work practice should be the core logic of future vocational education curriculum" and "the framework of practice-oriented vocational education curriculum." He believes that the curriculum structure of vocational education should be derived from work structures rather than disciplinary structures.

The development of vocational education curricula based on the qualification framework mainly involves data collection, industry research, and accurate understanding and positioning of industry job requirements. It involves the stratification of competencies and the formulation of industry talent standards. Based on these competencies, relevant teaching curriculum units are designed and implemented, and the curriculum evaluation mechanism is improved to ensure the quality of teaching.

2. Current situation and existing problems

In the teaching syllabus of "Fundamentals and Skills of Electronic Technology" in vocational schools, it specifies the nature and tasks of the course, teaching objectives, the structure of teaching content, teaching requirements, teaching implementation, and assessment and evaluation, providing recommendations for the implementation of teaching. The syllabus provides relatively clear regulations on the teaching content. However, it lacks clarity in terms of the difficulty of the teaching content, integration with industry standards, and comprehensive development of teaching standards and objectives. The main problems can be summarized in the following three aspects[3-4].

2.1. From the perspective of knowledge

The curriculum standards provide detailed requirements for students' knowledge. However, the methods for students to acquire knowledge and process information are not clearly defined. For example, in the syllabus [5], regarding the teaching requirements and recommendations for the decoder in the combinational logic circuit module, it states "understand the basic structure and working principles of common digital displays" and "learn to apply decoder displays by connecting digital display circuits." However, it does not explicitly require students to independently search for information on the "basic structure and working principles of common digital displays" or to independently design and connect the digital display circuits through self-reflection. It also does not require students to objectively evaluate their own performance and identify any problems encountered during the learning process. The syllabus mainly focuses on the knowledge that students need to possess, but lacks clarity in terms of the requirements for students to internalize that knowledge. Students may not understand the significance and value of learning the relevant knowledge, which hampers their self-awareness and may lead to self-doubt, contradictions, and a lack of motivation in learning.

2.2. From the perspective of skill

The curriculum standards provide detailed regulations on the professional skills that students need to possess. However, the requirements for the working process under standardized criteria are not clearly defined, and there is no explicit demand for students' information processing abilities, language communication skills, and mathematical logic operation abilities. The application of knowledge in "Fundamentals and Skills of Electronic Technology" is mostly reflected in specific circuit modules. The integration between teachers' instruction and "standardized techniques" is not closely aligned, making it difficult for students to transfer and apply knowledge in practical work contexts. For instance, in the syllabus, the teaching recommendation for the practical project of making a four-player quiz buzzer system states that "students should be able to install the circuit using flip-flops to achieve the required logical function." However, it does not require students to conceptualize how to design the circuit before installation and express it in written or oral form. It also does not set requirements for the mathematical logic operation abilities that may be needed in the process, such as using truth tables and Karnaugh maps or applying laws and properties to simplify expressions.

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2.3. From the perspective of competence

The syllabus does not clearly define the requirements for students' autonomy, responsibility, and innovation. Schools aim to cultivate talents that meet the needs of the market, industry, and enterprises. In addition to possessing the relevant professional skills, students also need to have a certain level of self-learning ability, teamwork and communication skills, as well as a strong sense of responsibility and innovation. These are important qualities that are often overlooked in school education but are crucial. The personality traits of modern students, influenced by their upbringing, tend to be more self-oriented. It is challenging for them to develop a strong sense of responsibility in their work, take ownership of tasks, and choose to retreat when facing problems, thereby hindering effective communication and collaboration. To address these issues, we need to address the overlooked aspects in the teaching process to better cultivate high-quality skilled talents[6].

Drawing on domestic and international qualification frameworks, we have developed a well-established qualification framework. The following diagram presents the standards and requirements for vocational school students in terms of knowledge, skills, and qualities within the qualification framework. It provides a clearer definition of the qualities that vocational school students should possess, as shown in Figure 1.

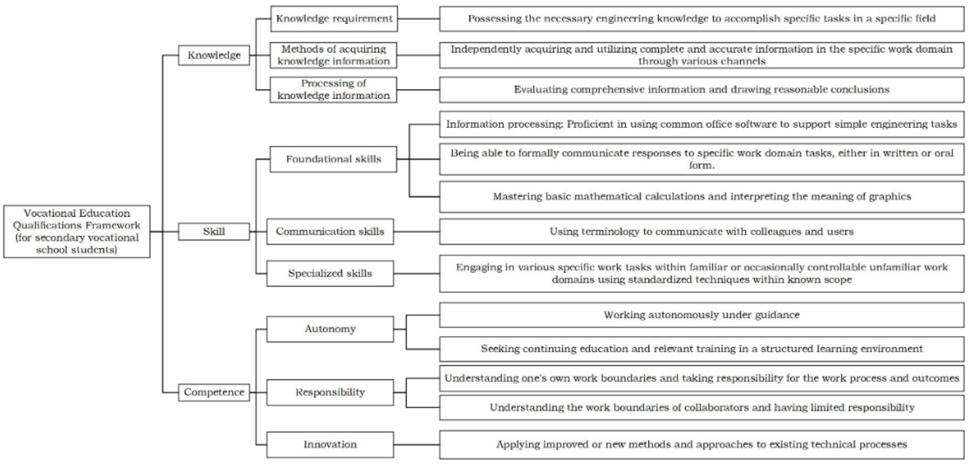

Figure 1: Vocational Education Qualifications Framework (for secondary vocational students).

3. The reform scheme of course designition

The course "Fundamentals and Skills of Electronic Technology" is a core course for students majoring in electronic information. By incorporating practical application designs into the core knowledge, it can help students better understand and apply the knowledge in real-life contexts. Taking the design of combinational logic circuits in the digital section as an example, a course reform plan is designed based on the vocational education qualification framework, with a teaching duration of 2 class hours (90 minutes) and utilizing LabVIEW simulation software as support.

LabVIEW software uses a graphical programming language that is intuitive and concise. For schools, integrating virtual simulation technology into the teaching process can save resources in terms of manpower, materials, and finances required for setting up practical training laboratories, while reducing the risk of damage to precision instruments. For students, the basic operation of this software is suitable for the cognitive abilities of vocational school students. It is easy to learn and can compensate for the monotony of learning theoretical knowledge in core courses, thus stimulating their interest in learning. For the software itself, it broadens its application field and scope, enhancing its usage in the education sector.

3.1. Learning situational analysis

We are targeting students in vocational colleges majoring in electronic information. They have already studied the analog section of the "Fundamentals and Skills of Electronic Technology" course, and have acquired theoretical knowledge in pulse and digital signals, as well as number systems and encoding. Most of the students have a relatively weak foundation in theory, making it challenging for them to recall previously learned knowledge. Therefore, it is necessary to provide appropriate review and

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recap sessions before introducing new topics. One of their strengths is their strong hands-on practical skills, and they have already learned the basic operations of LabVIEW simulation software. However, the class time allocated for this course is relatively limited, and some students may experience difficulties in transferring and digesting knowledge. Additionally, the usage of simulation software may be forgotten over time and requires regular practice. The class consists of 30 students.

3.2. Teaching content analysis

Design of a Call Circuit for Prioritizing Care for Critically Ill Patients (Design of Combinational Logic Circuit):

Provide students with a scenario: In a hospital department, there are four wards numbered 1, 2, 3, and 4. Patients are admitted to the wards in ascending order of severity, with the most critical patients assigned to ward 1 and the least critical patients assigned to ward 4. To prioritize care for critically ill patients, design the following call circuit, which includes call buttons A, B, C, and D installed in each ward. The corresponding duty room has four indicator lights: L1, L2, L3, and L4.

The requirements are as follows:

When button A in ward 1 is pressed, regardless of whether the buttons in other wards are pressed, only L1 should light up.

If button A in ward 1 is not pressed, and button B in ward 2 is pressed, regardless of whether buttons in wards 3 and 4 are pressed, only L2 should light up.

If buttons in wards 1 and 2 are not pressed, and button C in ward 3 is pressed, regardless of whether the button in ward 4 is pressed, only L3 should light up.

If buttons in wards 1, 2, and 3 are not pressed, and button D in ward 4 is pressed, only L4 should light up.

3.3. Analysis of instructional objectives

To align with the vocational education qualification framework for vocational school students, it is important to integrate its contents into the instructional objectives and course design. By designing instructional tasks as part of the learning objectives, it becomes easier to assess whether students have undergone the corresponding training and to evaluate their progress based on the completion of these tasks.

3.3.1. Knowledge

1) Knowledge Requirements

Students should have a basic understanding of the relevant knowledge related to combinational logic gates. They should be able to recognize the symbols for AND, OR, and NOT gates, understand their functions, draw truth tables, and simplify them into the simplest expressions.

2) Methods for Acquiring Knowledge

Students can acquire knowledge through pre-class preparation, independent research, and gathering relevant information. They should summarize the definitions, symbols, and functions of logic gates. Additionally, they should be able to independently review and practice the basic operations of LabVIEW simulation software.

3) Processing Knowledge Information

After the class, students are required to create individual summary reports that clearly outline their contributions within their respective groups and demonstrate their understanding of the circuits.

3.3.2. Competence

In the context of education, it refers to "competence" or "quality." However, it encompasses a broader meaning that includes various aspects of personal qualities, attitudes, values, and ethical standards. It implies a holistic development of individuals, encompassing intellectual, moral, cultural, and social dimensions. In an educational context, it emphasizes the cultivation of comprehensive abilities, including critical thinking, creativity, communication skills, teamwork, ethical awareness, cultural appreciation, and a sense of social responsibility[7-8].

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1) Autonomy

Students are capable of independently reflecting on the general steps involved in circuit design with the assistance of teachers and peers. They can conduct independent research by searching for relevant resources and learning videos related to logic gate circuits and combinational logic circuit design after class to expand their knowledge.

2) Responsibility

During group collaboration, students recognize themselves as team members and possess a sense of teamwork and responsibility. They provide assistance within their capabilities to help team members overcome difficulties, and they do not tolerate or indulge individuals with a mindset of taking shortcuts or being lazy without limits.

3) Creativity

Students demonstrate the ability to think creatively and adapt circuit design ideas to diverse front panel and block diagram designs based on practical considerations.

3.4. Analysis of teaching methods

1) Discussion-based Teaching Method

Through group cooperation, this teaching method enhances students' learning efficiency and optimizes their learning methods. It cultivates students' collaborative awareness and social skills, allowing them to experience the joy of success and strengthening their self-confidence. It also enables students to recognize the importance of teamwork and enhances their sense of teamwork and personal responsibility.

2) Guided Inquiry Teaching Method

Students, based on the given problem scenario and pre-reading tasks, engage in discussions with their peers, actively collect information, and independently think and construct circuit design solutions. After implementing the solutions, students reflect, evaluate, and summarize their own performance. This teaching method enhances students' abilities in self-directed learning, independent thinking, and teamwork.

3) Task-driven Approach

Under specific task scenarios (such as designing a call circuit for prioritizing care for critically ill patients in a hospital), students engage in learning with clear central tasks. During the exploration process, students' curiosity and sense of achievement are continuously stimulated, enhancing their interest in learning and desire for knowledge. This forms a positive learning cycle that cultivates students' abilities for independent exploration and the courage to venture into new territories.

3.5. Analysis of teaching resources

3.5.1. Traditional Media (Blackboard):

Traditional media refers to the use of a blackboard as a teaching tool in the classroom. It involves writing or drawing information on the blackboard using chalk or markers. The blackboard allows for visual representation of concepts, equations, diagrams, and other instructional content, enabling teachers to engage students in a classroom setting.

3.5.2. Modern teaching media (Student Computers, LabVIEW Software, PowerPoint, Projector, etc.):

Modern instructional media encompasses various digital tools and technologies used in teaching. This includes student computers, LabVIEW software, PowerPoint presentations, projectors, and other multimedia resources. These tools enhance teaching and learning by providing interactive, visual, and dynamic content that engages students and supports their understanding of complex concepts.

3.6. Analysis of teaching process

3.6.1. Before class

As a pre-class preparation, students independently review the course textbook "Fundamentals and Skills of Electronic Technology" and search the internet for relevant scientific materials to understand

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the definitions, symbols, and functions of logic gates. They also refresh their knowledge of basic operations in LabVIEW software. These activities serve as preliminary groundwork before attending the class.

3.6.2. In class

1) The first class(45min):

Students are given an explanation of the theoretical knowledge related to logic gates. Three students are randomly selected as representatives, and they write the corresponding knowledge content of AND gates, OR gates, and NOT gates on the board (including the meaning of the gates, circuit symbols, functions, and logical expressions). The teacher asks questions and makes corrections based on the students' explanations, engaging other students in the process (10 minutes).

The teacher corrects any misconceptions and summarizes the correct knowledge and experiences (5 minutes).

A problem scenario is presented, and students form groups of six (five groups in total) to interpret the scenario through group discussions (15 minutes). The groups discuss and propose their understanding and solution methods, followed by class-wide discussions (10 minutes).

The expected result of the discussion is as follows: When patient 1's light is on, regardless of the conditions of patients 2, 3, and 4, the corresponding L1 light must be on. When patient 2's light is on and patient 1's light is off, regardless of the conditions of patients 3 and 4, the corresponding L2 light must be on. When patient 3's light is on and patients 1 and 2's lights are off, regardless of the condition of patient 4, the corresponding L3 light must be on. When patient 4's light is on and patients 1, 2, and 3's lights are off, the corresponding L4 light must be on. Thus, it can be concluded that patient 1 has the highest priority, followed by patients 2, 3, and 4. This guides students to understand priority circuits.

The teacher then guides students to think about the steps for designing the circuit: analyzing the problem scenario, listing the cases, creating the corresponding truth table, simplifying the table, and building the circuit model based on the expression (5 minutes).

2) The second class(45min):

The problem scenario was analyzed, and each student, based on the circuit design analysis steps discussed in the previous class, wrote the truth table by listing the cases (5 minutes). As shown in the following Figure2.

A	B	C	D	L1	L2	L3	L4
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	0
0	0	1	1	0	0	1	0
0	1	0	0	0	1	0	0
0	1	0	1	0	1	0	0
0	1	1	0	0	1	0	0
0	1	1	1	0	1	0	0
1	0	0	0	1	0	0	0
1	0	0	1	1	0	0	0
1	0	1	0	1	0	0	0
1	0	1	1	1	0	0	0
1	1	0	0	1	0	0	0
1	1	0	1	1	0	0	0
1	1	1	0	1	0	0	0
1	1	1	1	1	0	0	0

Figure 2: The truth table.

The expressions for L1, L2, L3, and L4 based on the truth table are as follows:

$$L_1 = A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D + A\bar{B}C\bar{D} + A\bar{B}CD + AB\bar{C}\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD \quad (1)$$

$$L_2 = \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD \quad (2)$$

$$L_3 = \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD \quad (3)$$

$$L_4 = \bar{A}\bar{B}\bar{C}D \quad (4)$$

Students independently simplify the truth table using the previously learned laws of operations. They use the formula method to simplify the table and obtain the corresponding expressions, thereby enhancing their logical reasoning skills (10 minutes).

$$L_1 = A \quad (5)$$

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$$L_2 = \bar{A}B \tag{6}$$

$$L_3 = \bar{A}\bar{B}C \tag{7}$$

$$L_4 = \bar{A}\bar{B}\bar{C}D \tag{8}$$

Based on the problem scenario and the obtained formula results, students design a solution through group discussions. They consider what controls need to be placed on the Labview software's front panel and how the program block diagram should be connected to achieve the circuit's functionality. After devising the solution, students individually carry out practical operations (15 minutes), and one student representative from each group presents their findings (10 minutes).

According to the analysis, the front panel requires four Boolean input controls and four output controls. We can place four switches and four display indicators and modify their names accordingly. The program block diagram and front panel design are shown in the following Figure 3 and Figure 4.

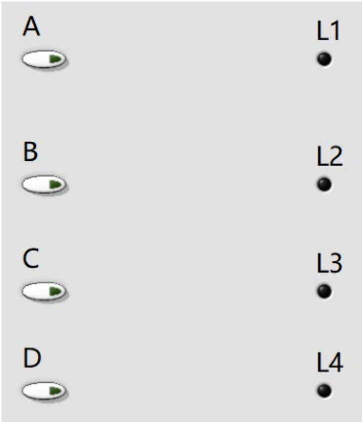

Figure 3: The front panel design.

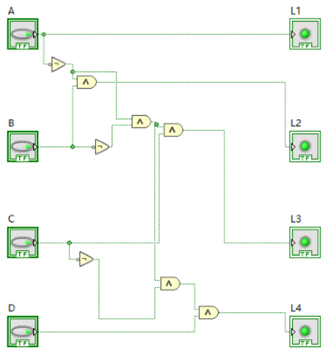

Figure 4: The program block diagram.

Based on the students' presentations, the teacher concludes the class by summarizing the basic knowledge of logic gates, the general steps for circuit design, and the design approach using Labview. The teacher also addresses any issues that arose during the class and assigns a task for individual reflections after the lesson (5 minutes).

3.6.3. After class

Students are required to complete an individual reflection, including their contributions and experiences within their groups, as well as their learning insights and conclusions from the lesson. They can describe any challenges encountered during the pre-reading phase, their understanding of logic gates and combinational logic circuit design after the teacher's lecture, any issues or summaries from their Labview software simulation practice, and their self-evaluation of their performance during the group discussion on circuit design.

3.7. Teaching evaluation and reflection

By assessing whether the teaching objectives were achieved in the pre-, during, and post-class stages,

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adjustments can be made accordingly. In the pre-class stage, it is important to evaluate whether students were able to complete the assigned tasks with autonomy and conscientiousness, and whether the difficulty level of the pre-reading tasks was appropriate. In the during-class stage, it is important to assess whether students engaged in productive interaction and communication with their peers, and whether the grouping method was effective. In the post-class stage, it is important to evaluate whether students were able to engage in self-reflection and draw objective conclusions.

Based on the defined teaching objectives, an assessment rubric can be developed. Students can use this rubric for self-evaluation and complete their individual reflections after the course. The reflections should include their performance in group work and their understanding and experiences related to the circuits. The teacher can use these reflections as part of the course assignments to assess students' level of comprehension. Through this process, students can actively apply and internalize their knowledge, identify areas for improvement, and objectively evaluate their own learning progress.

4. Conclusion

By reforming the curriculum teaching based on the qualification framework, the issues in traditional curriculum development have been addressed. The framework specifies the necessary engineering knowledge that students must possess to complete specific tasks in their respective fields, which serves as the foundation for problem-solving. The methods of acquiring knowledge are defined as the means and approaches for students to independently solve problems. The guidelines for knowledge processing enable students to evaluate and reflect on their problem-solving processes, facilitating active learning feedback.

The requirements for fundamental skills, communication skills, and specialized skills are clarified, incorporating virtual reality technology into teaching to enhance students' learning interest and compensate for the shortcomings in laboratory facilities. This integration also enhances students' ability to express their ideas and strengthens the connection between professional knowledge and real-world contexts.

Furthermore, the importance of autonomy, responsibility, and creativity in the learning process is emphasized. The focus is on students' holistic development, aiming to cultivate highly qualified applied talents who can meet the needs of the market and enterprises. Through objective evaluations of their performance during the learning process, students can develop a strong sense of self-efficacy.

Overall, the curriculum reform based on the qualification framework not only addresses the shortcomings of traditional teaching approaches but also promotes students' comprehensive development and fosters high-quality, application-oriented professionals that meet market demands.

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