Teaching Design and Practice of "Three-wide Education" Integrating into Combinational Logic Circuit Design

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Abstract: This article explores the integration of "Three-Wide Education" into the course 'Digital Electronic Technology' with a specific focus on the content related to the design of combined logic circuits. As education continues to evolve, the goals of higher education have shifted from simply imparting knowledge to nurturing students' holistic development and actively engaging them in societal progress. In today's social context, the cultivation of high-caliber electronic information professionals with a strong sense of social responsibility has become a central objective of higher education. Consequently, curriculum-based "Three-Wide Education" has gained prominence as a pivotal component of higher education reform. Drawing upon the thematic elements of "Three-Wide Education" within the chapter on combinatorial logic circuit design, this article embarks on instructional design. The primary objective is to seamlessly integrate knowledge dissemination with value-based guidance through practical exercises in "Three-Wide Education" within the curriculum.

Keywords: Combinational Logic Circuit Design; Three-wide Education; Teaching Design; Teaching Practice

1. Introduction

With the rapid advancement of information technology, the goals of educating students in electronic and information-related fields have evolved beyond traditional technical and practical skills. There is now a greater emphasis on nurturing students' moral and ethical qualities. In this context, reforms are necessary in the educational and instructional models of electronic and information-related programs, incorporating the concept of "Three-Wide Education" into the development and implementation of specialized courses.

Digital electronics stands as a foundational course within electronic and information-related programs. It serves as a critical foundation for subsequent courses like microcomputer principles and digital signal processing [1,2]. This course primarily explores the theory and practice of digital circuits, demanding high levels of critical thinking, innovation, and teamwork from students. However, traditional courses in combinational logic circuit design often prioritize the transmission of theoretical knowledge and practical training while neglecting the cultivation of students' moral and ethical qualities. Therefore, the challenge at hand is how to integrate the concept of "Three-Wide Education" into combinational logic circuit design, making it a pivotal subject in the ongoing reform of electronic and information-related education [3].

2. Curriculum Design and Teaching Methods

The content of 'Combinational Logic Circuit Design' is derived from the fourth section of the fourth chapter in the fourth edition of 'Fundamentals of Digital Electronics' published by Higher Education Press [4]. Before delving into this section, students have already acquired fundamental knowledge of circuits and mastered the logic functions of basic gates. This section serves as the focal point of the chapter and also establishes the groundwork for the subsequent study of sequential logic circuits, serving as a bridge between the two. This course is tailored for second-year students majoring in electronic and information-related fields. These students are characterized by their critical thinking, eagerness to experiment, strong practical skills, but a relatively limited interest in theoretical knowledge. Consequently, the teaching

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method in this section mainly adopts the BOPPS blended teaching mode, engaging students throughout the pre-class, in-class, and post-class phases to implement a flipped classroom approach.

This article integrates the concept of "Three-Wide Education" into the design and implementation of the ‘Combinational Logic Circuit Design’ course, enabling students not only to acquire professional knowledge and skills but also to nurture their sense of humanistic care, social responsibility, and innovation and entrepreneurship abilities [5]. This enhances students' overall qualities and competitiveness. For students majoring in electronic and information-related fields, this approach not only benefits their personal development but also aligns with society's demand for high-quality professionals. Therefore, integrating the concept of "Three-Wide Education" into the teaching design and practice of the ‘Combinational Logic Circuit Design’ course holds significant practical significance and profound impact [6].

3. Teaching Strategies and Practices

Firstly, the teacher guides the students in reviewing the concepts of combinational logic circuit analysis, leading them to contemplate the essence of logic design. Subsequently, group discussions are initiated to explore how to design logic circuits based on the required logical functions. Leveraging their existing knowledge, students can synthesize methods for designing combinational logic circuits. In this segment, the course incorporates "Three-Wide Education". It is emphasized that design is a critical aspect in the field of integrated circuits. Drawing from examples such as the challenges faced by Huawei and ZTE, the students are encouraged to promote national spirit, cultivate innovation, patriotism, and aspiration, strengthen their sense of national identity, and firmly uphold the Chinese position while embracing their responsibilities in the modern era [7].

Before class, the teacher had already sent the students learning materials and design tasks, i.e., design a three-person voting circuit. By checking the completion status before class, the teacher could carry out teaching in class to address existing problems. The first step is logic abstraction. Input variables A, B, and C were established to represent three mentors, with 0 indicating opposition and 1 indicating agreement. An output variable Y was used to represent the voting result, where 0 signified disagreement, and 1 represented agreement. The logical relationship between the output variable and input variables was defined as follows: When two or more out of the three variables A, B, and C had a value of 1, the function Y equaled 1. Otherwise, it equaled 0, following the principle of the minority obeying the majority.

Random student assignments were selected for presentation. Real-world problems were translated into logical questions, a fundamental skill that engineering students need to cultivate. The first step involved creating a truth table based on the logical relationship, as shown in Table 1. Using the truth table, the corresponding expression for Y was derived, as seen in Equation (1).

Table 1. Truth Table for the Three-Person Voting Circuit

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

$$Y=\overline{A}BC+A\overline{B}C+AB\overline{C}+ABC \quad (1)$$

Due to the fact that this expression is not in its simplest form, it requires a significant number of basic components in practical applications. However, electronic components often contain a large amount of precious metals and heavy metals such as gold, silver, and copper. Improper usage can lead to resource wastage, environmental pollution, and hinder sustainable development. Therefore, the next step involves the teacher guiding the students in simplifying the circuits.

The purpose of simplifying the expression is to make the logic circuit concise and the actual circuit simple, economical, and reliable. In this phase, real-life images of electronic-waste are presented, encouraging students to optimize real circuits sensibly. This approach instills a green, energy-efficient, and sustainable development perspective among students, integrating "Three-Wide Education" into the curriculum. There are two methods for simplification: one is the formula method, and the other is the Karnaugh map method. This article adopts the second method, as shown in Figure 1. Simplification yields the simplest function Y expression, as in Equation (2). Based on this simplified expression, the corresponding simplified logic circuit diagram can be constructed, as illustrated in Figure 2.

A \ BC	00	01	10	11
0			1	
1		1	1	1

Figure 1. Simplification of Karnaugh Map

$$Y=AB+AC+BC \quad (2)$$

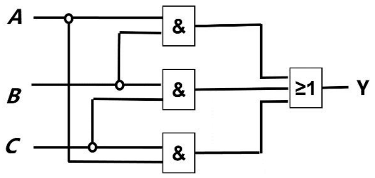

Figure 2. Simplified Logic Circuit Diagram of Three Person Voter

The teacher continues to provide guidance to students, helping them expand their understanding of designing cost-effective and practical combinational logic circuits for real-world applications. For instance, they explore the potential circuit design when utilizing 'NAND gates.' By posing pertinent questions at each stage, the primary objective is to reignite students' enthusiasm for learning. Students are encouraged to apply De Morgan's theorem to transform mathematical expressions, as exemplified in Equation (3). Subsequently, they are expected to generate corresponding logic circuit diagrams, as illustrated in Figure 3. During this phase, the teacher introduces the concept of 'seeking truth from facts.

$$Y = \overline{\overline{AB+AC+BC}} = \overline{\overline{AB}\cdot\overline{BC}\cdot\overline{AC}} \quad (3)$$

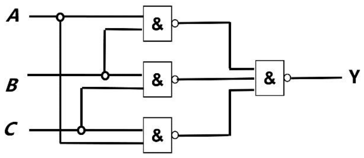

Figure 3. Circuit Diagram with NAND Gates

In this stage, the teacher steers students toward contemplating the notion that addressing real-world engineering challenges extends beyond adhering to simplistic templates. It requires the ability to adapt to specific circumstances, anchor one's approach in practicality, and refine practical skills. Simultaneously, students are encouraged to integrate their research in circuit theory with real-world production technologies, recognizing the mission and responsibility they carry in advancing their nation's technological landscape. This encourages students to align their academic pursuits with their nation's developmental imperatives, thereby charting a path to progress that harmonizes societal demands with personal growth and development. At the end of this lesson, assign practical homework to help students solidify their new knowledge while also constructing comprehensive mind maps.

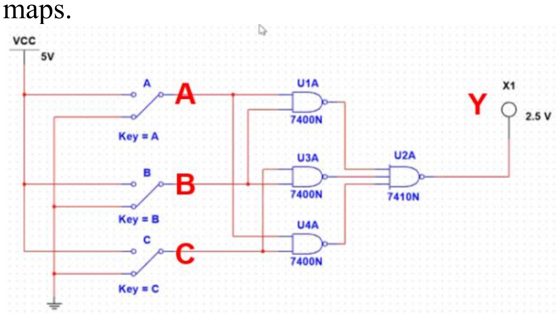

Figure 4. Multisim Simulation Validation

It is emphasized that knowledge derived from books, while foundational, remains inherently limited, and true comprehension necessitates practical experience. Practice is the ultimate litmus test for establishing the validity of theoretical knowledge, with theoretical principles being anything but abstract. Proficiency in employing simulation software is deemed indispensable for enriching both learning and investigative capabilities, nurturing innovation, and laying the groundwork for the analysis and application of integrated circuits. This proficiency contributes not only to the advancement of the semiconductor industry but also to the overall progress of the nation. Leveraging the familiar Multisim simulation software, students can verify the functionality of the aforementioned circuits, as demonstrated in Figure 4.

4. Implementation and Effect Evaluation

This lesson introduces combinational logic circuit design by initially analyzing combinatorial circuits familiar to students. It delves into the design methods of combinational logic circuits through practical applications, with a focus on cultivating students' independent inquiry abilities, as well as their patriotism and the enhancement of national cohesion and self-confidence.

When assessing the actual teaching effectiveness across the three teaching phases - pre-class, in-class, and post-class, this teaching seamlessly integrates elements of "Three-Wide Education" into the curriculum. Through approaches like case analysis and group discussions, it naturally ignites students' interest in learning, addresses diverse student needs, and enhances classroom interaction and student engagement. The assignment of specific tasks and practical projects assists students in consolidating their acquired knowledge, improving their practical skills, and enhancing their problem-solving abilities.

5. Conclusions

This teaching design and practice effectively incorporate "Three-Wide Education" through several means. Firstly, it guides students to focus on contemporary societal issues and cutting-edge topics, nurturing their sense of social responsibility and innovation. Secondly, it employs teaching methods such as classroom discussions and case analyses to encourage ethical reflection and moral judgment, fostering students' values and professional ethics. Additionally, through methods like group collaboration and project-based learning, it cultivates students' teamwork and leadership skills while promoting their awareness of innovation and practical competence. Lastly, by conducting course assessments and collecting student feedback, the effectiveness and acceptance of "Three-Wide Education" among students can be gauged, allowing for the timely adjustment of teaching strategies and methods as needed.

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