Redesign and Implementation of Project-Based Teaching Content for EDA Courses in Higher Education Institutions under the OBE Approach

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Abstract: This paper is guided by the OBE (Outcome Based Education) philosophy of engineering education accreditation and addresses the disconnect between theory and practice in traditional EDA (Electronic Design Automation) course instruction. It proposes a project-based teaching content restructuring reform method. Taking the Electronic Information Engineering program at Hengshui University as an example, this paper establishes a "needs-objectives-evaluation" closed-loop system based on the OBE model of engineering education accreditation. Centered on the student, this approach clarifies learning objectives, encourages personalized instruction and teamwork, emphasizes the practical application of learning and the cultivation of problem-solving skills, enabling students to better apply their knowledge to real-world work scenarios and enhance the practicality and value of their learning. Practice has proven that the improved project-based course teaching method enables students to complete system design through project collaboration, encouraging them to continuously challenge themselves and gradually enhance their capabilities. This model provides a replicable implementation paradigm for curriculum reform in electronic information-related majors and holds significant practical value.

Keywords: EDA Technology; Project-Based Teaching; OBE Concept; Tiered Teaching

1. Introduction

In recent years, with the development of 5G communications and AI (Artificial Intelligence), the global market size for FPGA (field-programmable gate arrays) has been steadily growing. According to Market Research Future's forecast, the global FPGA market size is expected to reach US$12.521 billion by the end of 2025. [1-3] In the domestic market, the FPGA market size is projected to reach US$12 billion.[4] With the support of advanced product manufacturing processes and the trend toward domestic chip production, China's FPGA-related industries have entered a period of rapid development. Currently, universities have gradually incorporated EDA technology into undergraduate and graduate curricula. According to relevant data, 90% of universities nationwide have introduced related courses at various educational levels.[5-6] As an important component of the electronic design course cluster, this course should focus on cultivating students' rigorous scientific literacy and fostering habits of diligent thinking and in-depth research to meet the demands of the electronic information era on students' knowledge structures and capabilities.[7-8] It aims to nurture future leaders in the communications field who possess a sense of mission and social responsibility.

2. Analysis of the Current Status of EDA Technology Courses in Higher Education Institutions

EDA is a critical software tool for chip design and manufacturing, spanning the entire process from chip implementation to system application. It plays a significant role in influencing the production efficiency and technological standards of the global integrated circuit industry. EDA technology is a core professional course in the field of electronic information engineering and serves as a crucial component of the electronic design course cluster. Given the continuous evolution and advancement of EDA technology, the curriculum content for EDA

technology courses must also undergo ongoing reform and innovation. Currently, the teaching of EDA technology courses in most domestic universities faces the following key issues:
Outdated experimental content that fails to keep pace with the times. Design methods centered on schematic diagrams cannot meet the requirements of modern complex electronic system design; simulation and debugging, which can only be conducted in the later stages of system design, cannot satisfy modern society's demands for design cycle efficiency and product cost-effectiveness [9].
Monotonous teaching methods and inflexible learning formats. Insufficient interaction between teachers and students prevents timely information feedback and clarification of doubts. The traditional teaching model results in a severe disconnect between theoretical and practical instruction, with reduced laboratory hours. For example, EDA courses are often allocated as theoretical + practical courses, offered as elective courses within the major, with limited allocated hours [10-11]. The explanation of FPGA-related knowledge in EDA courses is superficial, and students cannot receive adequate and effective training through traditional EDA course instruction.
Assessment methods are not flexible enough. In EDA course assessments, the large number of students leads to insufficient teacher attention. Evaluation criteria are difficult to quantify, making it impossible to assess students' true abilities, resulting in final grades that do not align with their actual proficiency levels.
Lack of natural integration of ideological and political content. In EDA-related courses, some universities lack specific and operational ideological and political teaching objectives, resulting in suboptimal educational outcomes. Ideological and political courses often focus solely on theoretical knowledge transmission, lacking in-depth exploration of social practice and practical application.

3. Reconstruction of EDA Technology Project-Based Teaching Content under the OBE Concept

The project-based teaching reform of EDA technology courses under the OBE philosophy aims to address the shortcomings of traditional EDA teaching, primarily through the following four aspects:
Integrating the OBE philosophy with project-based teaching to implement tiered instruction, introducing design-oriented, inquiry-based, and innovative experimental designs aligned with industry standards.

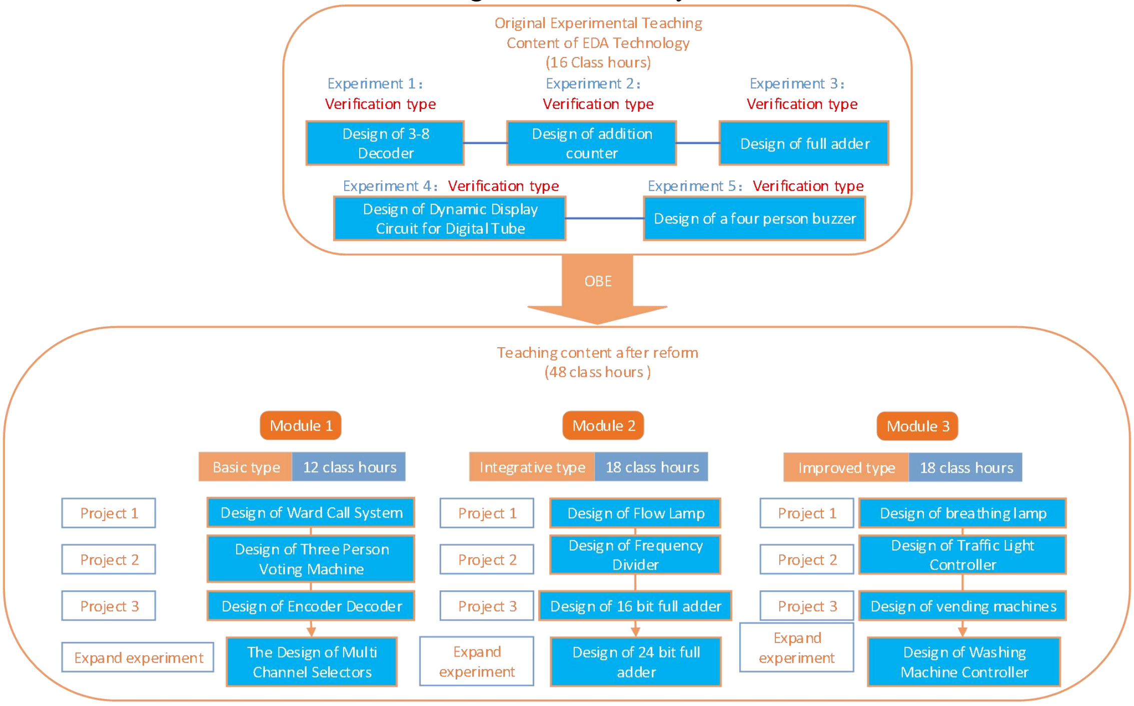

Figure 1. Curriculum Reform Based on the OBE Concept

As shown in Figure 1, the VHDL language is replaced with Verilog HDL, and the selection of application examples is optimized to align with corporate applications. Traditional verification-based experimental projects have been adjusted into three types of experimental projects: basic, comprehensive, and advanced. Expanded experiments have been added, with content and difficulty levels progressing step by step, and teaching being carried out in a tiered manner. The design content is derived from everyday life and has strong practicality, making it easy for students to understand and interesting for them. This allows students to experience the usefulness and feasibility of the knowledge they have learned, thereby stimulating their interest in studying their major and cross-disciplinary innovation in technology application.

Incorporate online teaching components to enable synchronized learning both online and offline. Online teaching offers advantages such as abundant resources, openness, and interactivity, making it highly popular among students. Many teaching and learning activities in this course are conducted online. Online resources include micro-lectures and simulated classroom videos, which students can use for previewing and reviewing. Before class, students can familiarize themselves with the application scenarios and primary functions of the system, and after class, they can use these resources to address any gaps in their understanding. Establish a course website with a dedicated learning section. Store videos detailing the usage processes and methods of the software platform used in the course on the website for students to access after class. Provide links to online forums related to the course to help students explore broader learning opportunities.

Project-based teaching is implemented using loose-leaf textbooks to guide students in self-directed learning, with a new experimental assessment model established. The original 60-person classroom is reformed into a 30-person small-class teaching format, with a team of four teachers providing targeted guidance for students in practical courses. As shown in Figure 2, the experimental teaching process is divided into three steps: pre-class self-study, in-class practical training, and post-class summary and expansion. Loose-leaf textbooks are used to focus on cultivating students' practical skills and problem-solving abilities. Each experiment is treated as a project, and the assessment method of attendance + writing an experimental report is adjusted. Offline, each project requires the writing of a design report, with two students forming a group to complete the experimental assignment and write the report as a team.

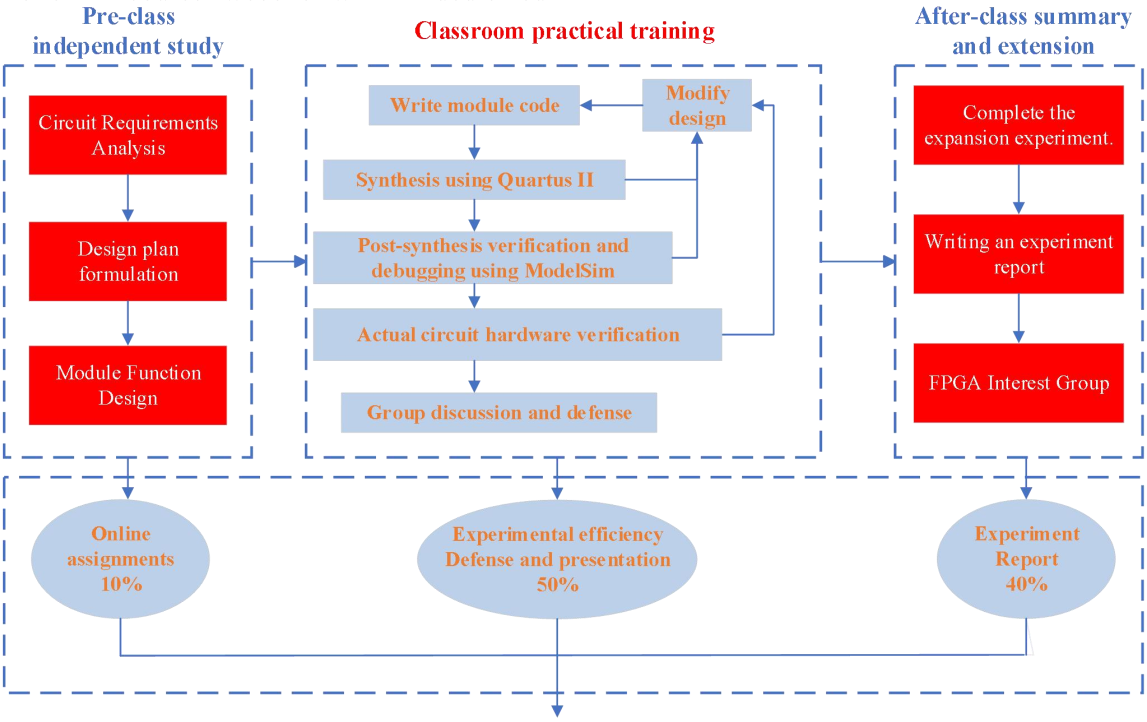

Figure 2. Project-Based Teaching Implementation Process

Examination scoring is composed of online assignments, presentations and demonstrations, and experimental reports. Students who submit accurate assignments, well-structured reports, clear presentations, innovative ideas, and successful demonstrations receive high scores. This effectively evaluates students' process-based competencies and eliminates plagiarism or identical work in experiments. During the assessment process, particular emphasis is placed on evaluating students' experimental processes, such as experimental efficiency and skill improvement.

Character development and moral education should be prioritized, with a focus on integrating ideological and political education elements. Traditional ideological and political education often emphasizes political knowledge and institutional frameworks, while modern ideological and political education increasingly incorporates contemporary issues such as national strategy, technological innovation, and global perspectives, enabling students to feel the pulse of the times and enhance the practical relevance of their learning. For example, by introducing the history of electronic technology development and combining it with content such as the industrial technology revolution, students can understand the role of technological progress in driving social development, thereby inspiring their patriotic sentiments and sense of responsibility.

4. Practical Reform of EDA Technology Education: Taking “the Design of a Ward Call System” as an Example

The ward call system is a foundational experimental case study following the reform of the “EDA Technology” course. It is a common electronic device in medical systems, highly practical, and easy for students to understand and find interesting. It allows students to experience the usefulness and feasibility of the knowledge they have learned, thereby stimulating their interest in their major and fostering cross-disciplinary innovation in technology application. This system is a common circuit system used by patients to seek assistance from doctors when doctors and nurses are not present. It facilitates mutual calling and intercom communication between nurses at the nurses' station and patients in hospital beds.

Based on the understanding of the internal structure of FPGA chips gained in previous courses, students are required to design a ward call system circuit using Verilog HDL language. The system structure is shown in Figure 3. Three switches simulate the call input signals from three patient rooms, with Room 1 having the highest priority, followed by Rooms 2 and 3 in descending order. A dynamic LED display shows the call signal number, displaying “0” when no calls are active and the highest priority call number when multiple calls are active. When a call is received, the corresponding indicator light illuminates, and a buzzer sounds for three seconds.

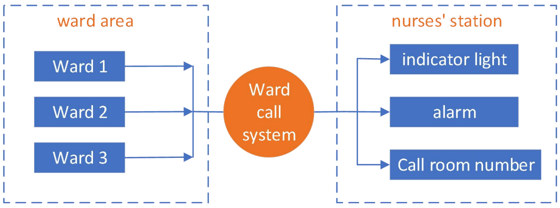

Figure 3. Structural Diagram of the Ward Call Systemfc

The experiment sets basic and advanced tasks for students, fully reflecting the tiered teaching reform. The basic task involves analyzing the design requirements of the ward call system circuit, analyzing the input and output requirements of the circuit, dividing it into modules, and completing the overall design. Draw the circuit analysis model, write the truth table based on the circuit design requirements, and list the logical function expressions. Write the code for each module in the Verilog HDL File editor window. Compile and check the code; if errors are found, modify and recompile. Observe the generated RTL view and examine the equivalent circuit structure. Assign pins according to the pin connection table for the toggle switch, LED, and FPGA. Use a download cable to load the corresponding sof file into the FPGA via the JTAG port and observe the experimental results. This experiment also sets an advanced task for students who have extra time: store low-priority calls, process high-priority calls first, and then process low-priority calls. If a call is not processed within 3 minutes, an alarm signal is output. Use a dual-color dot matrix to display the ward number of the call.

4.1 Pre-Class Preparation

The experiment process is divided into three steps: pre-class preparation, in-class experiment, and post-class summary. During the pre-class preparation phase, students are required to understand the principles of the ward call system control circuit based on design requirements, using the micro-lectures and simulated classroom videos prepared in advance by the instructor. They must complete the pre-class review questions and discuss design solutions in groups. Review the operational process of using Quartus 13.1 software for project setup, code input, simulation, debugging, and download verification.

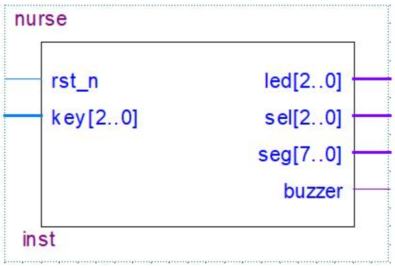

Figure 4. External Port of the Ward Call System

Based on the design plan, divide the system into modules, design the basic block diagram and control flow. The ward call system primarily consists of a call host installed at the nurses' station, call sub-units installed at the bedside in the ward, and a display screen at the nurses' station. Once someone presses the call button at the bedside in the ward, the host at the nurses' station emits an alarm signal, and the display screen simultaneously shows the bed number that made the call, allowing nursing staff to immediately proceed to the ward. The ward call system is named "top." According to the system's design requirements, its input/output ports are shown in Figure 4. The functions of each I/O port are as follows: 'key' is a 3-bit input signal used to indicate that a call signal has been issued from the corresponding ward. "rst_n" is a reset signal. LED is a 3-digit output signal used to illuminate the corresponding red indicator light, indicating that the corresponding ward has issued a call. SEL is a 3-digit output signal used to output the digit tube position selection signal. SEG is an 8-digit output signal used to output the digit tube segment selection signal. BUZZER is used to control the speaker to emit a buzzer sound.

4.2 In-Class Experiment

During the laboratory phase of the course, students must simulate each submodule and, after confirming that there are no errors, simulate the top-level design module. First, based on the system requirements, the entire system is divided into three modules: the call module (call): emits a call signal, with a red LED indicating the ward number corresponding to the call signal; the dynamic LED display module (number): displays the ward number corresponding to the call; and the buzzer module (buzzer): sounds for 5 seconds when a ward calls. The program is downloaded to the development board for debugging and functional verification. Under the guidance of the instructor, complete tasks such as module simulation, debugging, downloading, and verification, and keep records of each task, documenting the experimental results. As shown in Figure 5, after the source code is completed, input the stimulus signal for waveform simulation, observe the waveform diagrams of the input and output signals, and judge the correctness of the design logic based on the waveform diagrams. As shown in Figure 6, observe the generated RTL view and examine the equivalent circuit structure. In Figure 7, after querying and assigning pins according to the pin connection table, use the download cable to load the corresponding SOF file into the FPGA via the JTAG port, and observe the experimental results in Figure 8.

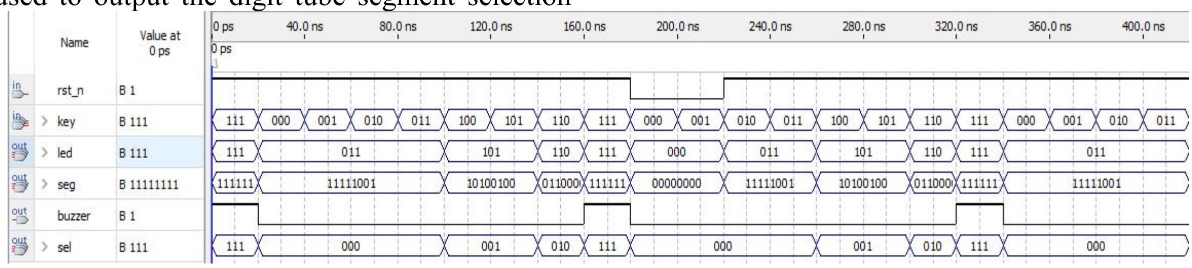

Figure 5. Waveform Simulation Diagram

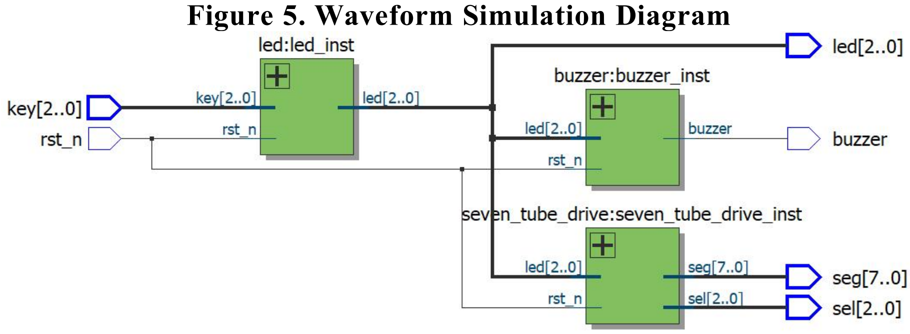

Figure 6. RTL View

To	Assignment Name	Value	Enabled
out buzzer	Location	PIN_68	Yes
in key[2]	Location	PIN_69	Yes
in key[1]	Location	PIN_70	Yes
in key[0]	Location	PIN_71	Yes
out led[2]	Location	PIN_136	Yes
out led[1]	Location	PIN_135	Yes
out led[0]	Location	PIN_133	Yes
in rst_n	Location	PIN_72	Yes
out seg[7]	Location	PIN_125	Yes
out seg[6]	Location	PIN_129	Yes
out seg[5]	Location	PIN_126	Yes
out seg[4]	Location	PIN_120	Yes
out seg[3]	Location	PIN_121	Yes
out seg[2]	Location	PIN_124	Yes
out seg[1]	Location	PIN_128	Yes
out seg[0]	Location	PIN_127	Yes
out sel[2]	Location	PIN_119	Yes
out sel[1]	Location	PIN_115	Yes
out sel[0]	Location	PIN_114	Yes

Figure 7. Pin Assignment

After downloading, if the operation of the development board differs from the design, guide the students to check their design, identify the issue, and re-download. Finally, conduct a group demonstration and acceptance, and answer the questions posed by the instructor.

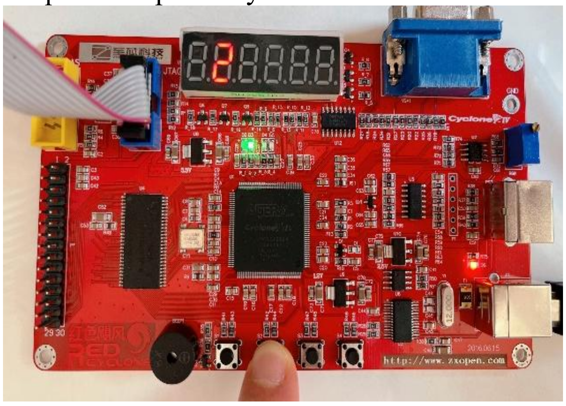

Figure 8. Verification

4.3 Post-Class Summary

During the post-class summary phase, students should carefully write their experiment reports, ensuring that the report format complies with course requirements. The report should summarize the experimental principles, design plans, experimental content, and experimental results. It should also address any issues encountered during the thought process and the methods used to resolve them. Students should engage in discussions to summarize design experiences and methods.

The purpose of this case study is to enable students to master the basic knowledge related to EDA technology, learn how to use common EDA development tools and software, understand the structure, principles, and selection criteria of programmable logic devices, master the structure, syntax, and basic usage methods of CPLD/FPGA hardware description languages, and acquire the methods for designing, describing, inputting, compiling, simulating, and downloading basic logic circuits and common electronic systems. Students should be able to independently complete the overall design of basic, commonly used small-scale electronic systems.

5. Conclusion

A project-based teaching reform for the course "EDA Technology Application Practice" based on the OBE concept has been proposed. Guided by the principles of "comprehensive, systematic, and innovative," the experimental teaching design adopts practical and implementable teaching methods such as "industry-education integration, project-led, task-driven, and tiered teaching." This approach promotes the deep integration of industry demands with EDA technology course experimental teaching, enhances students' engineering practical skills, and cultivates their comprehensive abilities.

Acknowledgments

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