Experimental Reform and Exploration of "Digital Electronic Technology" Course Based on BOPPPS Model

Zhongyang He[a], Suge Dong[b], Bo Gao[c], Zhuolin Li[d], Lu Guo[e*]

PLA Strategic Support Force Information Engineering University, Zhengzhou, China.

[a]zhongyanghe@foxmail.com; [b]dove0206@126.com
[c]galber@163.com; [d]335256320@qq.com
[e*]958580843@qq.com

Abstract. Given the challenges faced in the experimental session of the "Digital Electronic Technology" course in domestic universities, including limited student engagement, insufficient alignment with industry demands, and inadequate supervision of the experimental process, this article advocates for the integration of the BOPPPS model into experimental teaching. Utilizing the experiment of "Combinational Logic Circuit Reverse Analysis and Restoration" as a case study, the experimental teaching design is structured around six key stages: Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment and Summary. The empirical findings demonstrate that this innovative approach effectively addresses the issues inherent in traditional experiments, fosters student interest and ultimately enhances the overall teaching effectiveness.

Keywords: Digital Electronic Technology; Practical Teaching; BOPPPS Model; Reverse Analysis.

1 Introduction

The compulsory basic course "Digital Electronic Technology" occupies a pivotal role in the curriculum for electronics and information majors, serving as a crucial supporting course and bridging the gap in personnel training programs[1]. This course not only reinforces students' theoretical understanding of digital circuits but also instills a mindset for digital system design, sharpens engineering practical skills and establishes a solid foundation for the engineering realization of digital electronic systems and subsequent professional course learning. Consequently, practical teaching is an indispensable aspect of "Digital Electronic Technology." By seamlessly integrating theoretical and practical teaching and emphasizing the integration of knowledge acquisition, ability development and quality enhancement, we can not only deepen students' comprehension of knowledge but also cultivate their problem-solving abilities, foster a spirit of exploration and innovation, and ultimately enhance the overall quality of talent training[2].

Z. Zhan et al. (eds.), *Proceedings of the 2024 10th International Conference on Humanities and Social Science Research (ICHSSR 2024)*, Advances in Social Science, Education and Humanities Research 858,
https://doi.org/10.2991/978-2-38476-277-4_121

2 Challenges in Traditional Experimental Teaching

Despite the advancements and maturity achieved in the theoretical and practical teaching of "Digital Electronic Technology" over the years, the rapid pace of development and transformation in the new economy and industries has necessitated the adaptation of teaching methods to meet new societal demands on talent's knowledge, abilities and qualities. Consequently, "Digital Electronic Technology," as a cornerstone basic course within the electrical curriculum, faces even more stringent standards and greater challenges. Currently, there are primarily three challenges pertaining to the practical teaching methods and approaches employed in this course[3,4,5].

2.1 The Old Teaching Concept Leads to Low Participation of Students

The traditional teaching concept is generally teacher-centered and focuses on one-way knowledge transfer. Teachers decide what to teach and how to teach. In the curriculum setting, teachers often give the preparation content, operation process, precautions and expected experimental results, while ignoring the principal position and active role of students in the learning process. The new educational concept of "student-oriented and result-oriented" is not well implemented, resulting in low student participation, poor subjective initiative mobilization and little room for free experiment.

2.2 The Integration of Experimental Design Leads to the Lack of Tight Fit for Job Requirements

Most of the experiments of "Digital Electronic Technology" adopt standardized experimental kits for experimental teaching. Although these kits are convenient for unified management and teaching, the solidified experimental design usually only requires students to operate according to the established steps for the purpose of restoring and verifying basic knowledge, which involves little content such as solving practical problems and design thinking training. Meanwhile, this method lacks the training of students' creative and exploratory abilities. At the same time, these nested experimental designs are seriously divorced from the requirements of future jobs, which makes it difficult for students to quickly adapt to jobs after graduation.

2.3 The Single Assessment Method Leads to Weak Control of the Experimental Process

At present, most practical teaching methods are taught by the teacher, and then the students complete the experiment according to the requirements. The experiment assessment is mostly determined according to the final experiment results and the submitted experiment report. Formative assessment is not sufficiently reflected in the process of experimental assessment, which can not well evaluate the whole process of students' experiment development. Consequently, the exam results can not comprehensively judge students' practical ability and innovative thinking.

In order to cope with the higher requirements of talents training in various industries under the background of "New engineering", practical teaching should not only focus on implanting basic knowledge and training basic experimental skills, but also focus on cultivating students' practical and innovative ability. In order to solve the problems existing in the practical teaching of " Digital Electronic Technology" course, the teaching group has carried out the practical teaching reform and introduced the BOPPPS model in the practical teaching. This teaching experiment has achieved very good results.

3 Introduction of BOPPPS Teaching Model

BOPPPS model is an effective teaching design model proposed by Canadian Instructional Skills Workshop (ISW), which based on constructivism and communicative approach theory and focusing on students' participation and feedback, aiming at enhancing classroom teaching effect [6].

The BOPPPS model consists of 6 modules[7]:

①Bridge-in: Modules aim to engage students quickly in classroom instruction, piquing their interest in learning.

②Objective: The teaching objective serves as the guiding principle in classroom instruction, clarifying what knowledge, abilities, and values students will gain, establishing reasonable learning expectations.

③Pre-assessment: Pre-tests assess students' prerequisite knowledge to inform teaching adjustments and student understanding. Test questions should align with objectives and be concise.

④Participatory Learning: Central to BOPPPS, participatory learning encourages active student engagement through collaboration, discussion, and interaction. Teachers facilitate this process, stimulating students' enthusiasm and deepening knowledge comprehension.

⑤Post-assessment: This phase primarily assesses students' comprehension of the experiment content and their learning outcomes, ensuring they have met the established learning goals.

⑥Summary: As the final step in the BOPPPS teaching model, the summary mainly reviews the course content, reinforces students' knowledge, and inspires them to explore beyond the classroom. It also integrates ideological and political elements at appropriate times, facilitating students' transition from achieving knowledge and ability goals to attaining quality goals.

From the six modules, BOPPPS model can be regarded as a closed-loop teaching process model, which can help teachers to decompose the teaching process, find out the teaching blind spots, and improve the teaching effectiveness.

In the organization and implementation of teaching, this model effectively embodies the teaching philosophy of student-oriented learning and teacher-led teaching. In practical classrooms, teachers only emphasize the experimental precautions, while students are left to design their own experimental plans and conduct the actual operations. During the process, students discover problems independently, and teachers only guide and inspire them. Ultimately, students are encouraged to think independently, analyze and solve problems by themselves. This not only fully mobilizes students' subjective initiative but also cultivates their practical and innovative abilities[8].

4 The Exploration of Practical Teaching Based on BOPPPS Model

This article takes the "reverse analysis and restoration of combinational logic circuits" experiment as an example. Based on an unknown experimental circuit board, it comprehensively uses the analysis and design methods of combinational logic circuits, adopts the idea of "reverse analysis", infers and restores the schematic diagram of the circuit board, and then conducts simulation verification of the schematic diagram. It uses breadboard to restore the circuit and proposes an improved circuit design scheme. The experiment introduces the BOPPPS model for teaching design, which facilitates precise control of each experimental step, guides students to dare to think and explore, improves students' participation in experiments, enhances their ability to analyze and solve problems and practice innovation, and ultimately achieves good teaching results (see Figure 1). The specific organizational implementation steps are as follows.

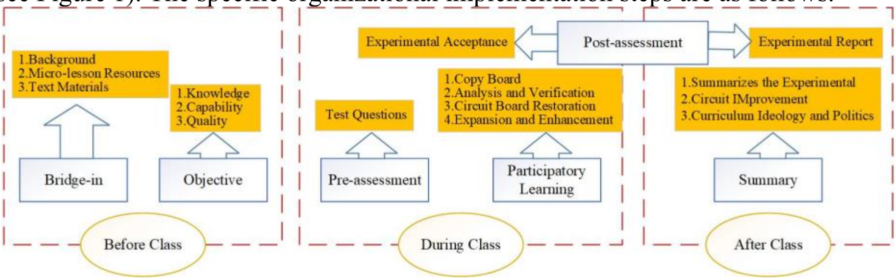

Fig. 1. Overall design framework of the experiment

4.1 Classroom Introduction (Budge in)

Budge in is the key process to judge whether the lesson is successful or not. Using the international and domestic current political events as a starting point, the experiment introduces the practical application requirements of combinational logic circuit analysis and design in real-world positions. It presents the background of the experiment to spark students' interest in this topic and stimulate their internal motivation to learn with patriotism. On this basis, by combining the knowledge taught in the corresponding chapters of the theoretical course, pre-class learning materials are distributed and pre-class assignments are given to help students grasp the basic knowledge of PCB circuit boards and familiarize themselves with the functions and usage methods of mid-scale devices on the board involved in the relevant chapters, laying a solid foundation for the successful completion of the experiment[9].

4.2 Teaching Objectives (Objective)

This experiment is aimed at the students' post ability needs and sets up three levels of teaching objectives: ①Knowledge objectives. Be familiar with the implementation function and use method of common medium scale combinatorial logic circuit integrated chip, master combinatorial logic circuit analysis and design method; ② Capability objectives. Using the idea of "reverse analysis" to restore the circuit, with the help of simulation software to realize the circuit design, master the engineering module design method; ③ Quality objectives. Exercise the ability to analyze and solve problems, cultivate the spirit of non-exploration, truth-seeking questioning and teamwork, and cultivate a scientific, standardized, rigorous and meticulous, down-to-earth style[10].

4.3 Pre-Class Testing (Pre-assessment)

The pre-test content for this experiment is primarily based on the guidance materials distributed to students in the introduction section and the pre-class assignments they were given to prepare. By integrating the content of the "Reverse analysis and restoration of combinational logic circuits" experiment, an open-ended circuit design question is cleverly designed to not only assess the effectiveness of students' pre-class preparation but also strongly correlate with the content of the current experiment. The title of this experimental design is that using adder 74LS283 to design the addition of two three-bit binary data $A_2A_1A_0$ and $B_2B_1B_0$, and utilizing the numerical comparator 74LS85 to determine the magnitude relationship between the sum and the decimal value of 10. At last, the comparison result will be displayed through a light-emitting diode. This question serves to test the effectiveness of their self-study before the class.

4.4 During Class Teaching (Participatory Learning)

In order to increase the participation of students, better control the experiment rhythm and guide the experiment process more finely, this experiment is designed into four stages.

①Copy Board Stage. The one-hour class session is primarily dedicated to students using a multimeter to measure the connectivity between various components on the circuit board. The course team has designed this segment with two key aspects in mind. Firstly, the introduction of modular thinking, where the circuit board is divided into four modules. Correspondingly, students are grouped into teams of four, with each student responsible for copying only one module. This approach not only exercises students' collaboration skills but also improves the efficiency of copying the board. Secondly, an experimental record sheet is designed to facilitate students in documenting the connection relationships between chips, saving time spent on copying and drawing the chips.

②Analysis and Verification Phase. The stage spans a one-hour class session. Initially, a brief summary is given on the progress of the copy board stage, correcting any issues encountered by students during the process. Following this, students are instructed to delve into the analysis of the copied board, examining the connective relationships and functional implementations among various modules. Through discussion, they consolidate their understanding of the overall functionality achieved by the circuit board. Finally, the use of Proteus software is employed to simulate and verify the analysis results. This step not only validates the analytical findings but also familiarizes students with the functional capabilities of each module, facilitating a deeper comprehension of theoretical knowledge. The entire process serves to integrate theoretical understanding with practical application, enabling students to have a more comprehensive grasp of the subject matter.

③**Circuit Board Restoration Phase.** After the simulation is completed, a summary is conducted on the experimental situation during the students' simulation verification phase. This summary aims to further familiarize students with the functions of each circuit module and correct any errors encountered during the simulation. Subsequently, students are tasked with utilizing a breadboard and the provided components to restore the actual functionality of the PCB circuit board. Once the breadboard is assembled, the circuit undergoes a power-up test. This phase spans two class hours and emphasizes guiding students to plan ahead when inserting components, debugging by module, and strengthening their engineering mindset.

④**Expansion and Enhancement Phase.** To further cultivate students' innovative spirit, an expansion component is specifically designed for the experiment. This phase focuses on encouraging students to apply their learned knowledge to independently improve and design the provided circuit. Students are guided to experiment with different circuit implementation schemes using the theoretical knowledge taught in class, emphasizing the cultivation of their questioning spirit and analytical problem-solving abilities. The goal is to foster a mindset that challenges conventional wisdom and encourages creative thinking in solving practical engineering problems.

4.5 After Class Testing (Post-assessment)

This experiment adopts the formative assessment method of experimental acceptance and experimental report, and each part is 50%. Classroom acceptance is mainly set up in each stage of the experiment assessment content, including pre-class homework, board copying, simulation, board insertion and safety operation. The experimental report is scored comprehensively according to six contents: experimental principle, problem analysis, circuit reduction, experimental record, improvement plan and standard integrity.

4.6 Summarize Feedback (Summary)

This section introduces the background of this experiment again, focuses on cultivating students' patriotism in conjunction with current events, summarizes the experimental situation, and provides feedback on experimental issues. The entire experimental process cultivated students' teamwork spirit, engineering modular thinking, and reverse thinking. In the stage of circuit improvement, the aim is to enhance students' ability to flexibly apply knowledge and cultivate their scientific questioning spirit. This type of experimental teaching not only helps students become more familiar with the analysis and design methods of combinational logic circuits, but also enables them to truly understand the essence of "reverse analysis" thinking, and cultivate a rigorous, meticulous, and down-to-earth research style.

5 Conclusions

In order to enhance the teaching effect of the experimental course of "Digital Electronic Technology", the research group introduced the BOPPPS model in the experimental teaching, and carried out the analysis and demonstration with the example of "Reverse analysis and restoration of combinational logic circuits". As a comprehensive experiment in the course of "Digital Electronic Technology" in our school, this experimental project has been continuously offered for many years, with about 19 classes per session in the past three years. The experimental scheme has been effectively verified, the experimental objectives have been successfully achieved, and the experimental results have received unanimous praise from both teachers and students. Supported by this experimental project, the course team has successively won the grand pride in the Experimental Teaching Case Design Competition for Basic Courses of Electrical and Electronic Engineering in Henan Province, one first prize and one second prize in the university-level teaching achievement awards. Next, the course team will further optimize the BOPPPS model and combine it with the OBE concept to introduce it into other classroom practices of the "Digital Electronic Technology" course. To enhance students' ability to analyze and solve problems, enhance their awareness of exploration and innovation, and focus on enhancing their comprehensive design and practical abilities in digital circuits, so as to cultivate talents that meet the requirements of " New Engineering ".

References

1. Zhang Y Z, Zhong Z G, Sun X L. Experimental Teaching Design of Digital Circuit Based on BOPPPS Model [J]. Journal of Electrical & Electronic Education, 2020(42):151-154. https://kns.cnki.net.
2. Zhang L, Du X Y, Li D X, et al. First-Class Course Teaching Design and Practice Based on the BOPPPS Model: A Case Study of Basic Electronic Technology Course [J]. Higher Education Journal, 2023, 9(21): 95-98. DOI:10.19980/j.CN23-1593/G4.2023.21.023.
3. Xiao W, Yu S X, Kou N. Application Research of BOPPPS Model in the Course of "High-Frequency Electronic Circuits" [J]. Journal of Educational and Instructional Technology,2022(14):149-152. https://kns.cnki.net.
4. Liu J. Innovative Teaching Design Based on the BOPPPS Model: A Case Study of Supply Chain Management Course [J]. College Education, 2023(11): 37-39. https://kns.cnki.net.
5. Pang Y M, Li D D, Zhang J Y. Teaching Design and Practice of the Entire BOPPPS Process Assisted by Course Resources: A Case Study of the "Introduction to Information Security" Course [J]. Journal of Beijing University of Electronic Science and Technology, 2023,31(3):99-107. https://kns.cnki.net.

6. Luo Y, Fu S J, Li T. Exploring Classroom Teaching Reform from the Perspective of the BOPPPS Instructional Model [J]. Computer Education, 2015(06): 16-18. DOI: 10. 16512 /j.cnki.jsjjy.2015.06.005.
7. Zhou W, Zhong W. Analysis of the Connotation of the BOPPPS Instructional Model [J].College Education,2018:112-115. https://kns.cnki.net.
8. HUANG R, YANG J, ZHENG L. The Components and Functions of Smart Learning Environments for Easy, Engaged and Effective Learning[J].Int. J. Educ. Media Thchnology,2013,8:4-14.
9. Mumovic D. Designing intelligent teaching and learning spaces: what do we know?[J].Intelligent Buildings International,2015,7(2-3):61-63.
10. Clementscroome D. Intelligent Buildings: An Introduction[J]. Crc Press,2013.