Optimization and Practice of the practical teaching system of the Digital Electronic Technology

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Abstract. In view of the issues in the practical teaching of the Digital Electronic Technology, which include outdated practical teaching content, insufficient innovation and comprehensiveness, redundant teaching methods, and a single assessment model, this paper proposes an optimized design for practical teaching content, teaching methods, and assessment mechanisms. The proposed plan adopts a deep integration of theory and practice, flexible expansion based on needs, a combination of multiple teaching models, and a comprehensive assessment mechanism. It adds design experiments and innovative research experiments to enhance the comprehensiveness and innovation of the practical teaching content. Various educational concepts and methods are integrated to form an optimized teaching method that combines multiple models. A comprehensive assessment mechanism is also designed. Through the optimized design of practical teaching courses for the Big Data Engineering, significant teaching achievements have been achieved. The proposed optimized practical teaching plan can effectively address the issues in practical teaching and better cultivate students' overall quality and innovative spirit.

1 INTRODUCTION

With the profound changes of science and technology, the continuous development of various integrated and interdisciplinary new disciplines and new majors such as artificial intelligence, unmanned systems, and big data has presented new requirements for the practical teaching construction of basic courses such as the Digital Electronics Technology [1][2]. To meet the needs of various new majors in talent cultivation, our university has successively opened new majors such as artificial intelligence, unmanned systems, and big data engineering in multiple colleges in recent years, accelerating the cultivation of new professional talents. After several years of the exploration and practice of the Digital Electronic Technology course team in our school, it is found that the following problems exist in traditional practical teaching.

1. The content of practical teaching is outdated and lacks innovation and comprehensiveness. The traditional practical teaching for the Digital Electronics Technology course mainly targets traditional disciplines such as communication engineering and electronic science and technology [3][4], focusing on simulations and practices of basic principles, unit circuits, and simple digital systems. However, it cannot meet the requirements of new disciplines for innovative and comprehensive practical content. Moreover, previous practical teaching examples are outdated and have not kept up with the times. Different new majors have varying needs for practical teaching content, so it is necessary to tailor the teaching content and select according to needs during the implementation of practical teaching. On the other hand, practical teaching is severely disconnected from theoretical teaching, making it difficult to apply theory to practice effectively, resulting in students having a shallow understanding of theoretical knowledge and inflexible application.

In recent years, the proposal of curriculum ideological and political education has put forward new requirements for practical course construction [3]. How to integrate patriotic enthusiasm, collaborative exploration, rigorous and practical workstyle, and other excellent engineering qualities into practical teaching in the context of practice course content, to achieve the integration of knowledge, ability cultivation and value shaping, is a new challenge for practical teaching.

2. The flexibility of experimental development is insufficient, and the teaching methods are redundant, which cannot meet the needs of students to carry out experiments anytime and anywhere. Traditional practical teaching relies too heavily on experimental equipment in the laboratory, and students are unable to complete practical teaching tasks once they leave the laboratory. This contradiction was particularly prominent during the pandemic period [5][6].

On the other hand, with the continuous advancement of the teaching reform in our school, the course practice of the Digital Electronic Technology has put forward a variety of teaching methods and concepts such as CDIO (Conceive-Design-Implement-Operate), PBL (Project-Based Learning), OBE (Outcome based education), etc. [7][8][9]. However, if there is no scientific design, it will lead to the chaos and disorder of multiple teaching

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methods, which will affect the teaching effect. How to adopt appropriate blended practice teaching methods to improve the comprehensive quality of students is worthy of in-depth study.

3. The practical teaching assessment mode is not detailed enough, and the whole process cannot be quantitatively assessed. In the past, the practice assessment method focused too much on outcome-based assessment, and there was little examination of students' ability and quality [4][9][10]. In the process of experimentation, the experimental process and experimental details are not strict, which leads to students' lack of understanding of the experimental principles and processes and cannot well cultivate students' ability to unite and collaborate and explore and innovate. The assessment methods for practical teaching lack procedural and hierarchical aspects, leading to excessive limitations in assessment results. Therefore, traditional outcome-oriented assessment methods for practical teaching can no longer meet the needs of new major talent cultivation, and there is an urgent need to explore a full-process, procedural assessment mechanism.

2. Optimized Design of the practical Teaching

The Digital Electronics Technology is an introductory and mandatory course for students majoring in information engineering, artificial intelligence, unmanned systems, and big data in our university. It mainly covers topics such as logic algebra, gate circuits, combinational and sequential logic circuits, memories, FPGA (Field Programmable Gate Array) and CPLD (Complex Programmable logic device), waveform generation and shaping, analog-to-digital and digital-to-analog converters, etc. The course has strong theoretical, practical, and operational characteristics, and plays a crucial role in the overall talent cultivation system [1].

To solve the practical problems encountered in practical teaching, this paper optimizes the design of the practical teaching system framework, teaching mode and assessment mechanism of practical teaching to meet the new requirements of the new major.

2.1. Optimal design of the practice teaching system

To adapt to the practical teaching needs of multiple emerging majors, this paper proposes a set of practical teaching optimization plans that integrate theory and practice deeply, flexibly expand according to needs, integrate multiple teaching models, and conduct comprehensive assessments throughout the process, as shown in **Fig. 1**.

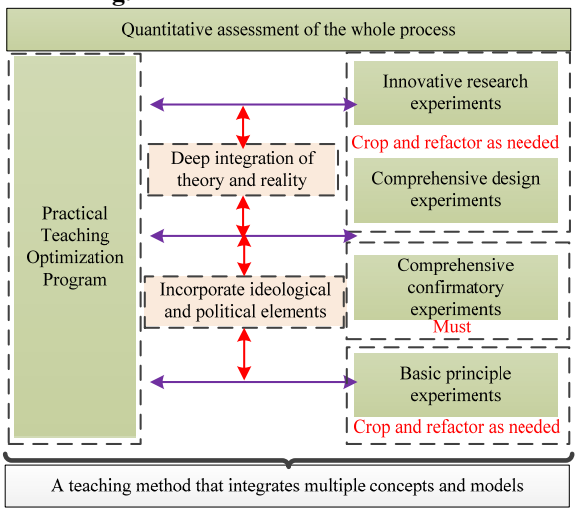

Fig. 1. Practical Teaching Optimization Program Layout Diagram

2.2. Optimal design of the practical teaching content

Table 1. List of knowledge structures for the practical teaching

Category	Practical content	Optimization and Design
The Basic Experiments	(1) Identification and use of commonly used electronic devices	Tailor and adapt to different majors for different majors
	(2) The use of instrumentation	
	(3) The use of EDA tools	
	(4) Design and implementation of typical digital logic circuits	
The Comprehensive Experiments	(5) Experiments involving comprehensive knowledge of the course or multiple related knowledge points of the course	At least 2 or more theoretical knowledge points are integrated for design.
The Design Experiments	(6) They are both comprehensive and exploratory, and They mainly focuse on the flexible application of theoretical knowledge.	Combined with the characteristics of modern electronic systems, the designs are simple and minimal.
The Innovative research experiments	(7) Experiments with the nature of research and exploration are designed according to the research fields of different disciplines.	Combined with the frontier of the discipline for design exploration

In terms of the optimal design of practical teaching, to improve the innovation and comprehensiveness of practical teaching content and highlight the hierarchical nature of practical teaching content, this paper combines the requirements of different new majors and the innovative development of digital technology. And with the help of a variety of modern practical teaching methods, a flexible knowledge framework of practical teaching with deep integration of theory and reality is formed, as shown in **Table 1**

Table 1 divides the whole practical teaching into four levels: the basic experiments, the comprehensive experiments, the design experiments, and the innovative research experiments. The difficulty and innovation increase in turn.

2.3. Integration of multiple teaching modes

The diversification of teaching modes is mainly reflected in the fact that there are many but not chaotic, unified, and orderly. There are nearly ten teaching methods used in the course of the Digital Electronic Technology in our school, including case-based teaching method, heuristic teaching method, task-driven teaching method, OBE teaching method [5], PBL teaching method [6], CDIO teaching method, etc., and the development methods include flipped classroom, online teaching, offline teaching, MOOC teaching, smart teaching, etc. The teaching philosophy includes student-centered, comprehensive development concept, diversity concept, personalized concept and so on.

After the unremitting efforts of the course group in the early stage, a teaching philosophy that "emphasizes comprehensive quality education, combines with teaching practice, and supplements with personalized, diversified, and other concepts" has been explored and formed. And, combined with the characteristics of the course, a teaching model that "focuses on CDIOC (Conceive- Design- Implement- Operate- Conclusion), emphasizes pre-class, in-class, and post-class, and supplements with various methods for optimization" has been formed to carry out practical teaching. So that there is unity in thinking and a main thread in the method. In addition, we use the pocket experimental box of " Hardwood Classrooms " for teaching. Students can use the virtual instruments and experimental devices in the pocket experimental box to conduct experiments anytime and anywhere after class. In class, students will combine the experimental results obtained after class, and use actual instruments and instruments to complete the design and development of digital systems.

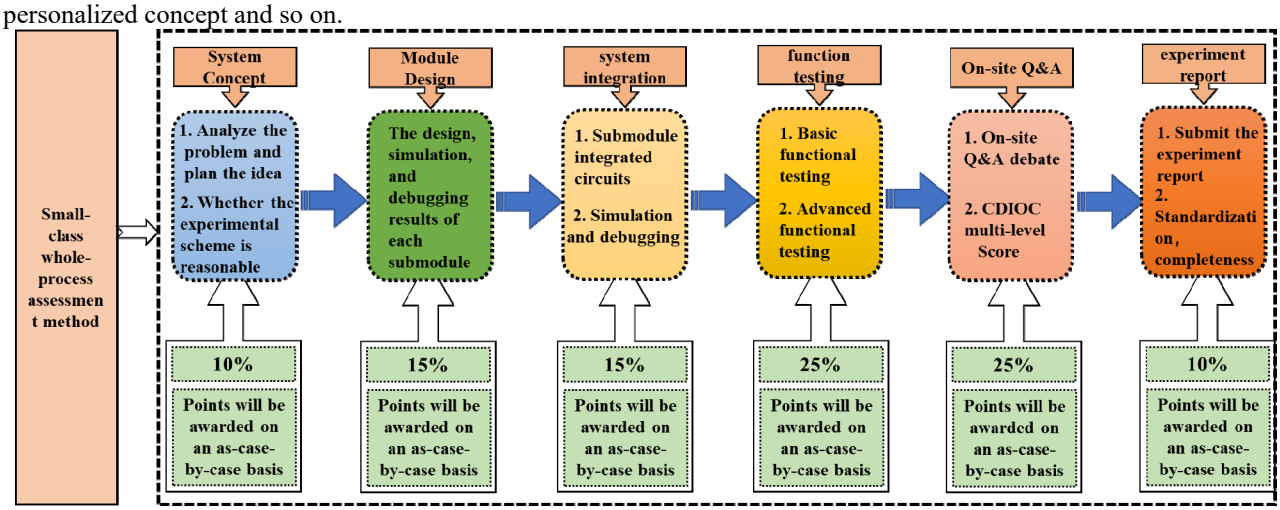

Fig. 2. Practical Teaching Optimization Program Layout Diagram

2.4. The design of the whole process quality assessment mechanism

To comprehensively evaluate students' knowledge, qualities, and abilities, the course group has researched and designed a set of small-class, whole-process quality assessment mechanism, as shown in **Fig 2**.

The assessment mechanism mainly focuses on quantitatively evaluating the entire development process of a modern digital system, including system concept, module design, system integration, function testing, On-site Q&A, and experiment report. And design personalized inspection content and assessment points based on different practical content to comprehensively evaluate students' abilities. Among them, the assessment of ability mainly focuses on the group discussion, experiment completion, and classroom performance of students in the above six assessment links; the assessment of quality mainly focuses on the embodiment of innovative and breakthrough spirit in experiments and the sense of responsibility and mission in teamwork.

3. Teaching Model

Taking the practical teaching of Big Data major in our school as an example, this paper illustrates the optimization and design of the practical teaching of the course Digital Electronic Technology.

In terms of teaching content optimization and teaching methods, since the big data engineering major has not learned other basic electrical courses such as circuit analysis before the course, it is necessary to explain and practice the basic knowledge of electricity such as electronic instrumentation and circuit analysis before practical teaching, to lay a solid foundation for the analysis and design of combinatorial and sequential logic circuits.

The basic experiments have the characteristics of simplicity and foundation, and mainly use tutorials, after-class simulations, and tests to teach. The comprehensive experiments mainly test students' grasp of combined and sequential logic circuits knowledge in theoretical courses.

The comprehensive experiments utilize combinational logic circuits such as data selectors,

encoders/decoders, and adders, as well as sequential logic circuits like registers and counters, to complete comprehensive analysis and design of digital circuits. Such experiments include the design of password locks, referee voting circuits, and answering devices based on MSI.

The Design experiments mainly focus on combining the characteristics of modern electronic systems to design simple minimum systems, to flexibly apply the theoretical knowledge of the digital electronics technology. For example, based on FPGA, students can design multi-function digital clocks, complete PWM experiments, UART serial communication, and other experiments.

The innovative research experiments mainly involve designing experiments that align with the professional directions and requirements of the later stages of the Big Data specialty, with the aim of examining and cultivating students' comprehensive qualities of independent exploration and bold innovation. For example, students may design and implement experiments on memory sharing and communication based on CPU+GPU architecture or develop experimental systems for handwriting recognition based on FPGA, intelligent image detection and recognition, intelligent voice analysis and processing.

In terms of practical teaching mode, the course group adheres to the teaching philosophy of comprehensive quality education, and tailors teaching methods to different teaching content and students, emphasizing the cultivation of personalized innovation abilities. The blended teaching method of the Online-Offline is adopted, and the implementation is carried out based on the CDIOC teaching model. Before class, the Hardwood Classroom Pocket test box and online pre-revision video are pushed to students, so that students can flexibly complete the preview and operation of the practice in the dormitory. The class pays attention to the guidance and assessment of the key nodes of the whole process. After class, online classes such as Rain Classroom can be used to complete the summary and reflection of experiments in a distributed manner. To improve the quality and effect of practical teaching, small class teaching of less than 15 students per class is adopted.

In terms of the whole process quality assessment, more attention is paid to the process of comprehensive quality assessment. At the knowledge level, it pays attention to checking students' understanding of basic knowledge and experimental principles in 6 links. At the level of quality, the performance of students in online and offline classes, practical collaboration, and language expression in six links are mainly examined. At the level of ability, it mainly examines the role of students in the practice of team learning, which can be completed through questionnaires, student assessments, etc.

4. Teaching Outcomes

In the past five years, the Digital Electronic Technology course team of our school has carried out reforms and practices in terms of practical teaching content, teaching mode, assessment mechanism and other aspects in response to the different practical teaching needs of a variety of new majors and has built a wealth of teaching resources such as practical case library, practical ideological and political database, and online practice videos. In addition, the course team has undertaken the practical teaching tasks of basic courses in more than 10 majors of our school and has cultivated thousands of outstanding students. The team has applied for more than 30 education and teaching projects, and won more than 30 awards in national, regional, provincial, and ministerial experimental case competitions. the practical teaching system structure constructed in this paper can adapt to the practical teaching requirements of a variety of new majors and cultivate many new scientific and technological innovation talents.

5. Conclusion

To solve the practical teaching problems encountered in the practical teaching process of the Digital Electronic Technology course and adapt to the teaching requirements of a variety of new majors, this paper optimizes the practical teaching design of the course, which mainly includes the optimization design of practical teaching content, the integration of multiple teaching modes, and the optimization of the whole process quality assessment mechanism. The optimization of practical teaching content is mainly combined with the theoretical teaching content of the Digital Electronic Technology, sorts out the existing practical teaching content, supplements design experiments and innovative research experiments, and solves the problems of outdated content, lack of comprehensiveness and innovation, and lack of combination of theory and practice. The integration of multiple teaching models combines various teaching philosophies and models, achieving a unified mindset and a clear methodological approach. The comprehensive assessment mechanism focuses on the process-based assessment throughout the course, emphasizing the assessment of knowledge, qualities, and abilities. Finally, this paper further elaborates on the content and key points of the optimized design of practical courses based on the practical teaching of our university's Big Data major. The teaching results in the past five years have shown that the optimization of practical teaching for the Digital Electronic Technology proposed in this article is more suitable for cultivating talents with new majors and has high flexibility and expandability.

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