Blended Teaching Design Based on Intelligent Learning Environment

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Abstract. To build a high-quality classroom, blended teaching design was carried out using the "six-step" ("judgment needs, objective setting, content design, strategy selection, resource allocation, and effect evaluation") teaching design method based on the concept of intelligent teaching. A general framework diagram of a "learning-centered" curriculum design was designed, and an intelligent learning environment based on online experimental platforms—Rain Classroom, MOOC of Chinese universities, and PTA—was created. The four steps of the traditional teaching process were decomposed into online and offline links and implemented respectively, which improved students' participatory learning effect in the course of Data Structure. Finally, the teaching effect was evaluated by comparing students' performance.

Keywords: Blended teaching · data structure · MOOC · Rain Classroom · Intelligent Teaching

1 Introduction

In March 2021, the Ministry of Education issued the Code for the Construction of Digital Campus in Colleges and Universities (Trial), aiming to promote the deep integration of information technology and education and teaching. Nowadays, when applied to intelligent classroom teaching, the prospering information technology not only adds fresh vigor to teaching, but also changes students' learning methods [1]. Blended teaching is not a simple combination of online and offline learning methods, and the recombination of teaching and learning methods exposes teachers to many challenges and puts forward higher requirements for their teaching ability [2]. However, the survey shows that our teachers' blended teaching ability is still in the exploratory stage [3].

The course of Data Structure is a basic professional course, serving as an important foundation for such courses as Fundamentals of Compiling, Operating Systems, and Database Principles [4]. Many teachers have explored blended teaching to figure out how to carry out the teaching reform of the Data Structure course [5–9]. However, there are some problems in the concrete implementation of the blended teaching mode, such as the combination of online and offline surfaces, substantial separation, one-way static

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online teaching, lack of interactions, and the failure of the Internet to penetrate offline teaching links [10].

In this research, the original "six-step method" ("judgment needs, objective setting, content design, strategy selection, resource allocation, and effect evaluation") was adopted to carry out the blended teaching design according to the teaching practice of the Data Structure course in our university. In March 2021, the research group promoted and exchanged the results of the six-step curriculum design method in the seminar and observation activities organized by the Army. In this research, how to design the course under the guidance of the "six-step method" was introduced in detail, including teaching objective setting, teaching content selection to match the teaching objectives, design of effective teaching strategies to implement teaching content, interactive design to stimulate students' independent thinking and active learning, teaching resource allocation, and effect assessment.

2 "Six-step Method" of Course Teaching Design

When thinking about the foothold of teaching design, teachers should consider not only correct courses, but, more importantly, correct teaching. The various links of curriculum design are interactive and interdependent, so the internal logic of each link of curriculum design should be reasonably established from the dimensions of elements, structures, functions, behaviors, and performance with the holistic view and the overall view, thus ensuring the scientific design.

Guided by the OBE concept and driven by the six questions in Table 1, therefore, the "six-step method" ("judgment needs, objective setting, content design, strategy selection, resource allocation, and effect evaluation") of curriculum design shown in Fig. 1 was investigated and formed through the reverse design idea by reference to the classical ADDIE teaching system organization model with talent training demands of the logical starting point. The goal, content, strategy, and resources were determined successively according to the demand. From the aspect of the effect, the latter ensured the achievement of the former goal in turn. Finally, an organically interconnected and iteratively upgraded closed loop was formed through effect evaluation and feedback improvement.

Compared with the past traditional curriculum design, the "six-step method" of curriculum design highlights the consciousness of structure and function, which shifts curriculum designers' focus to how to correctly design curriculum teaching from how to correctly design curriculum teaching.

The "six-step method" of curriculum design solves the macro-design problem of the course. Therein, the six elements show a closely associated and mutually supporting network-like relationship structure, and each bears the basic function described by each question. This structure can facilitate the whole teaching system to operate more scientifically and reasonably, thereby guaranteeing better teaching efficiency and effect.

3 Objective Setting

As said by an American educational psychologist Bloom, "Effective learning begins with knowing exactly what the goal is." The reverse setting of teaching objectives should be adopted based on the "students' development-centered" concept, which should be

Table 1. 6 Questions Corresponding to the Six Steps (owner-draw)

Step No.	Questions to be thought upon in curriculum design	Design elements
1	Why are students required to learn this course?	Judgment needs
2	What is the learning goal?	Objective setting
3	What content should be selected to help students achieve these learning goals?	Content design
4	What are the ways to help students achieve their learning goals?	Strategy selection
5	How to ensure that students can achieve these learning goals?	Resource allocation
6	How do we know that students have achieved these learning goals?	Effect evaluation

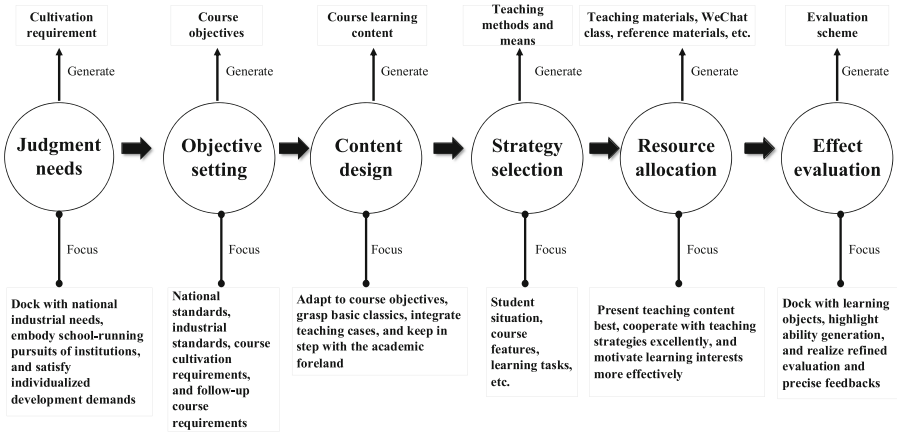

Fig. 1. "Six-step Method" of Course Teaching Design (owner-draw)

a comprehensive setting from students' graduation post requirements, talent training standards, talent training programs, and the correlation with the first and subsequent courses. A suitable teaching objective serves as a very significant starting point. After teaching objectives are established, students can be clear about their own efforts and tasks to be completed. To clarify the basic requirements and orientation of the course, the talent training standards of universities and the talent training programs for professional positions were surveyed. To figure out the individualized teaching needs of the course, students' post requirements and individualized development demands were explored. On this basis, the training objectives of this course were further refined, i.e., knowledge objectives, ability objectives, and affective attitude and value objectives (Table 2).

Table 2. Teaching Objectives (owner-draw)

Training objectives	Concrete content
Knowledge objectives	1. Discriminate the features and application modes of four basic structures. 2. Understand and apply basic theories and methods such as data structure and algorithm concept, and algorithm design and evaluation. 3. Know what a good algorithm is, how to design and choose a good algorithm, and be able to design and analyze problems with a certain complexity.
Ability objectives	1. Be able to write complete and correct programs based on C language. 2. Use the core ideas like modularization, formal description, and abstract modeling to realize structured division of the task, efficiently manage the task collaboration pattern, and solve problems based on computational thinking.
Affective attitude and value objectives	1. Complete tasks and enhance leadership and management ability through team collaboration, configuration optimization, and scientific selection of appropriate methods. 2. Improve the quality of scientific thinking with an innovative spirit and creative consciousness. 3. Be firm in ideals and beliefs, strengthen dedication and sense of responsibility, and stimulate learning motivation.

4 Teaching Content Design

The academic situation was detailed by a questionnaire survey. The survey data revealed that 1. Good source of students and a good foundation for prerequisite courses. 2. Students' strong desire for knowledge. 3. Good learning attitudes. 4. Strong learning dependence, 50% of students were not used to preview. Therefore, students should be guided to learn independently so that they can be gradually transformed into college students with independent thinking and learning ability.

To achieve the teaching objectives, three core teaching issues were focused on: First, how to foster characters and civic virtue and cultivate military talents? 2. How to carry out intelligent teaching and realize precise teaching and individualized learning through information technology? 3. How can we not lower the standard of personnel training when the number of hours is reduced? These three issues were turned into four concerns that the course should focus on, namely, ideological and political education and military application of the course; precise teaching and individualized learning; algorithm design and programming abilities; future development ability. Then, the curriculum design was implemented accordingly.

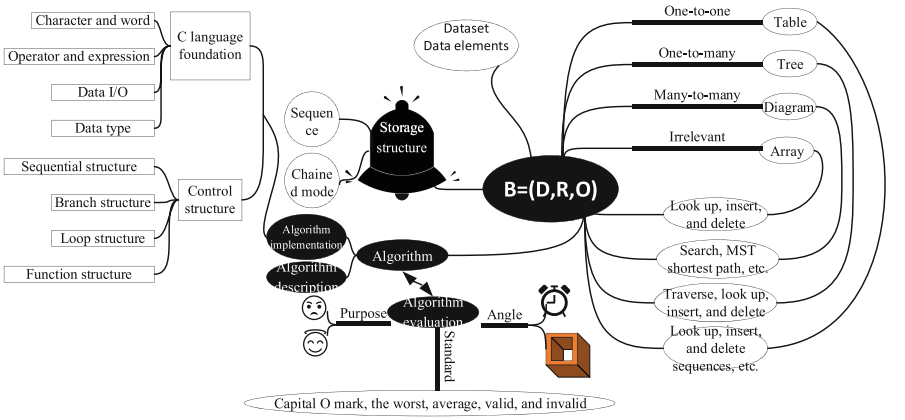

Fig. 2. Curriculum Knowledge System Diagram (owner-draw)

Based on the support degree for the curriculum objectives and starting with "four natures and one degree" (two natures and one degree + soul-casting + war-fighting), a curriculum knowledge system (Fig. 2), a practical teaching system (Fig. 3), and a knowledge structural relationship diagram (Fig. 4) conducive to the generation of wisdom were investigated and formed according to the idea of "grasping the classics, integrating into the military field, and introducing the frontier," so as to lay a foundation for solving problems.

4.1 Focus on "Deep Integration" and Recombine C Language and Data Structure Content

The knowledge system focuses on the ability to describe algorithms with C language, abandons uncommon grammatical details, highlights the research on basic principles and methods, updates the content by keeping in step with the forefront of disciplines, broadens students' horizons, and makes the course content more vivid. From the overall perspective, the teaching content should be reorganized, and the C language and data structure should be organically integrated.

4.2 Focus on "The Unity of Knowledge and Action" and Build a "Two-Level and Three-Class" Practical Content System

The practical teaching system is an advanced practice system that adapts to the teaching objectives and faces different levels. Macroscopically, the practice is divided into two parts: the curriculum experiment and the second classroom. Microscopically, the experimental properties are divided into three categories: basic, design, and comprehensiveness. This system provides different ability training environments for students of different levels, and endows students with more sense of acquisition.

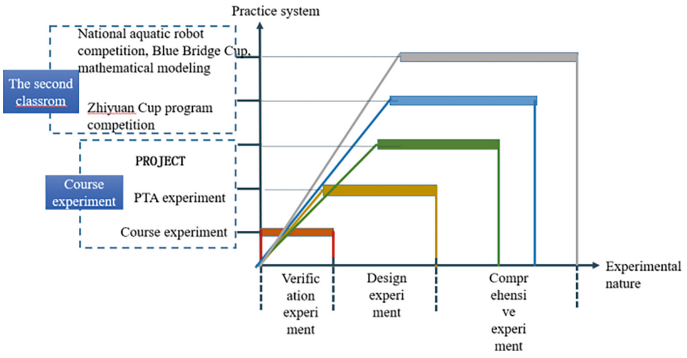

Fig. 3. Relationship Diagram Between Practice System and Experimental Nature (owner-draw)

4.3 Focus on "Four Natures and One Degree" and Build a Three-Layer Content Architecture

Efforts should be made to grasp the basic refined content, condense the core of discipline theory, combine and expand the teaching content modules, and enhance the tailoring nature of course content. Therefore, the content hierarchy of the three-level structure shown in Fig. 4 is constructed. With the military application at the upper level as the traction, the professional knowledge points are strengthened at the middle level, and the theoretical foundation of the discipline is forged firmly at the bottom level. Moreover, computational thinking runs through all content, which not only supports the curriculum standards and lays the foundation for the cultivation of ability and quality but also paves the way for the systematic thinking of "where it starts is also where it ends."

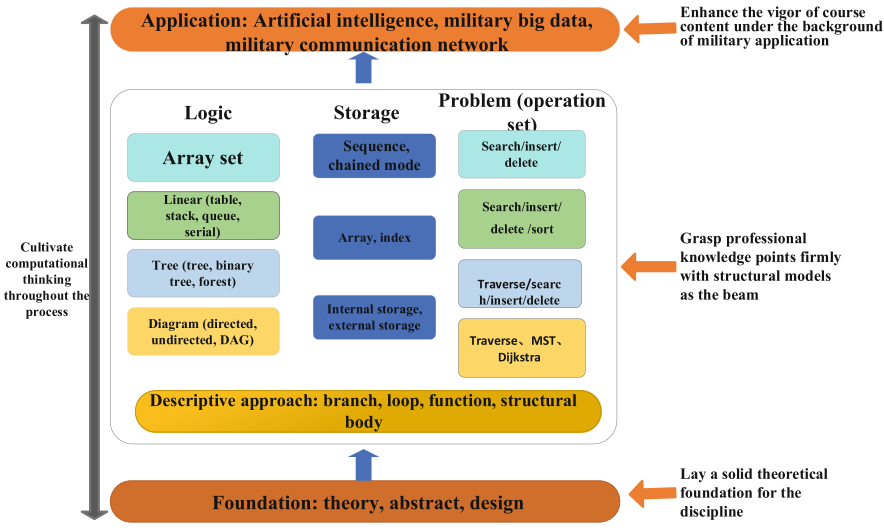

Fig. 4. Content System Diagram of Three-Layer Structure (owner-draw)

5 Teaching Strategy Selection

How to effectively implement the teaching content? Blended teaching was adopted; namely, different teaching methods and means were selected according to different kinds of training standards. The traditional 4-step teaching process was decomposed into online and offline links, respectively, where the former is self-learning based on knowledge points while the latter is mainly used to accomplish higher-order teaching objectives, cultivate the ability to analyze and solve problems, and solve complex problems using through computational thinking based on the needs of military applications.

An intelligent learning environment is required to support the effective implementation of online and offline blended teaching methods and means. With the help of information technology and digital teaching resources, an "online and offline integrated" intelligent learning environment—"MOOC/SPOC + Rain Classroom + PTA Online Experimental Platform"—was established. Then, the blended teaching design was implemented based on this intelligent learning environment (Fig. 5), which provided favorable support for precise and individualized teaching. Students' online learning levels could be accurately known by using the MOOC/SPOC platform for self-learning and self-test, after-class tests, and online teacher-student interactions. Specifically, using the Rain Classroom to complete the open test in class could not only realize the efficient teacher-student interaction but also obtain students' test data. The PTA online programming training platform was used both in class and after class to perform gradient breakthrough-making type training and examination, which could automatically evaluate the correctness of code and give real-time feedback on students' learning data. Based on diversified process data such as SPOC + PTA + Rain Classroom, every student could recognize their own achievements and progress, form their own personality characteristics, and realize colorful and diversified development.

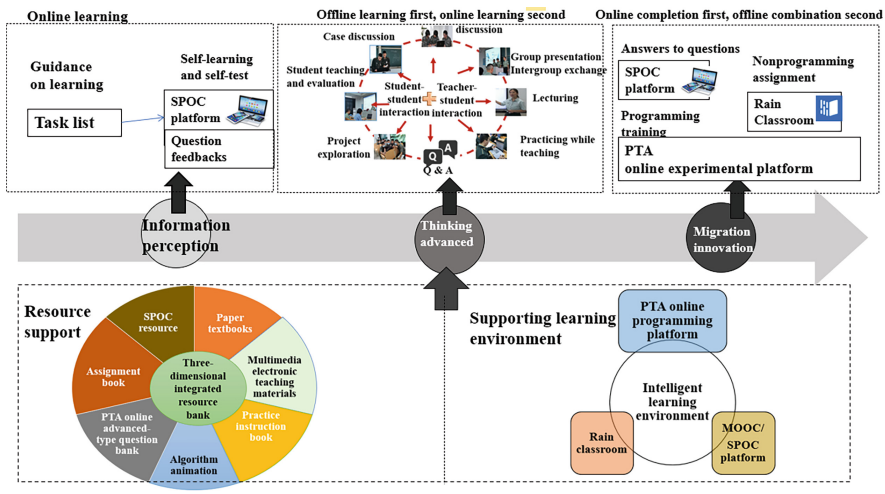

Fig. 5. Blended Teaching Design Based on Intelligent Learning Environment (owner-draw)

Online courses could help students improve their self-learning ability and the depth and quality of offline classes, which, however, reduced the direct teacher-student interactions to some extent. In offline classes, a variety of teacher-student interactions and student-student interactions were adopted to complete the flip class. Specifically, multiple flip class forms, such as spear-against-shield (question preparation before class and discussion and answering in class), practicing while teaching, group assistance, group discussion, and project inquiry, to guide students to realize high-quality interactive learning and solve problems.

6 Resource Allocation

How to solidify teaching design results? The answer is to establish curriculum resources. The resources accumulated over multiple years were integrated with two selected national high-quality online courses of Zhejiang University and the Army Engineering University of PLA as (small private online courses (SPOCs). The curriculum design group has built abundant teaching resources, including self-compiled paper textbooks, self-developed digital resources, self-built MOOC resources, self-compiled Rain Classroom test questions, and the PTA question bank, which meet the course teaching needs with high quality (Fig. 6).

The research group has also built an ideological and political case database and a military case database for this course. In the ideological and political design of this course, the focus has been on "soul-casting and war-fighting", excavating the ideological and political elements of the course, and enriching the teaching content with military cases. On the one hand, masters' stories and the scientific thinking methods contained in the course have been mined from the development of program design and data structure. On the other hand, cases have been abstracted from actual military activities and scientific research projects, enriching the teaching content and strengthening students' sense of military soul, feelings of home and country, and sense of mission and responsibility.

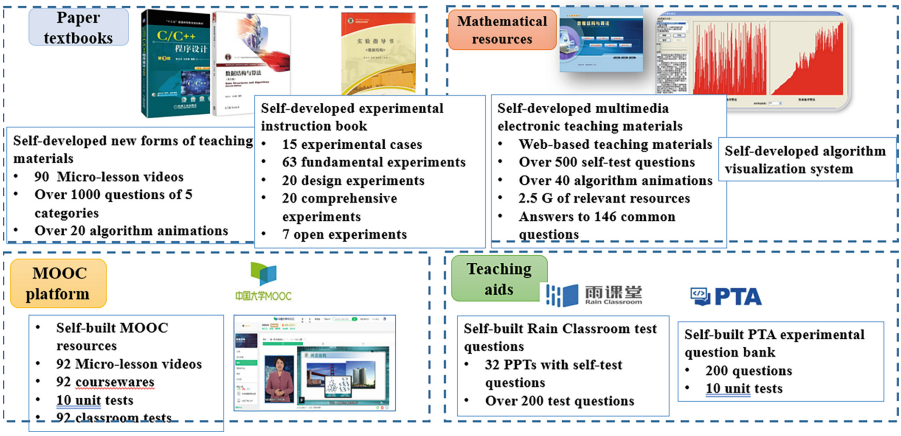

Fig. 6. Resource Bank of the Course (owner-draw)

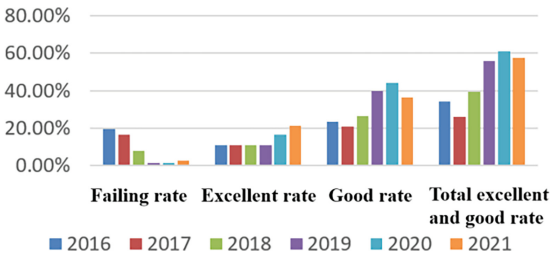

Fig. 7. Students' Statistical Performance in Final Exams during 2016–2021 (owner-draw)

Through combing and summarization, a number of ideological and political elements have been listed according to the chapters and knowledge points, and flexible and diverse integration methods have been designed based on the content elements, so as to achieve the function of ideological and political education, like moistening things in silence.

7 Effect Evaluation

After completing the above five-step design, the teaching process can be started. What is the effect of teaching implementation? Teaching evaluation is required. This course has a great influence on the teaching of follow-up courses, needing to grasp students' learning state widely, deeply, and truthfully. Therefore, the multi-factor weighting method (60% of final exam + 10% of SPOC + 5% of PTA test + 5% of Rain Classroom + 5% of PROJECT assignment + 5% of mid-term exam + 5% of assignment after class) was adopted to evaluate students' achievements comprehensively, and different ability indicators were assigned to each teaching link (Fig. 7).

Since the curriculum reform, the final exam results have been improved obviously, with a declining failing rate and an increasing excellent and good rate year by year. Moreover, significant progress has also been achieved in process results. According to students' feedback, their computational thinking ability has been enhanced, and they have won rewards in national discipline competitions time and again.

8 Conclusions

For the course of Data Structure, the ingenious "six-step" (judgment needs, objective setting, content design, strategy selection, resource allocation, and effect evaluation) teaching design method was used to reshape the new model of the teaching process. Then, a three-dimensional integrated resource database was established. Next, a "Rain Classroom + MOOC + PTA" supporting an intelligent learning environment was created. Moreover, the traditional 4-step teaching process was decomposed into online and offline links for respective implementation, and 25% of the total class hours were applied to the flip class, which met course needs with high quality and effectively achieved course teaching objectives. In the future three years, our research will focus on deeply mining online learning data statistics, deep integration of curriculum design into the ideological and political education of this course, etc.

9 Fund Projects

Collaborative Education Project of University-Industry Cooperation, Ministry of Education (202101151012, 202101244033), the second batch of pilot virtual teaching and research room construction by the Ministry of Education (Letter No. 216 of General Office of the Ministry of Education [2022] 13), National Education Science National Defense and Military Education Subject "14th Five-Year Plan" Research on Curriculum Reform for Deep Integration of Personalized Learning and Intelligent Education (JYKT-D2022013), Project on the Exploration of Virtual Teaching and Research Laboratories in Army Colleges and Universities (Letter of Participation and Training [2022] No. 215), Construction Project of "Data Structures and Programming," the first batch of high-quality courses in the Army Engineering University's 14th Five-Year Plan and 2021 Teaching Achievements Project Development Project.

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