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Exploration and practice of hybrid teaching model for computer fundamental courses under the background of new engineering

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Abstract: With the deepening advancement of new engineering, computational thinking has become a key capability for interdisciplinary integration. Traditional university computer fundamental courses face numerous challenges in teaching methods, content, and practical aspects, making it difficult to meet the needs of talent cultivation in the new era. This paper takes the course "C Programming Language" as a pilot, focusing on the goals of "value shaping, personalized development, thinking training, and professional integration", and constructs a new hybrid online-offline teaching model based on OBE (Outcome-Based Education) philosophy. Through hierarchical learning objectives, case-based reconstruction of teaching content, tiered promotion of experimental practice, and optimization of diversified multi-level evaluation systems, distinctive features such as "hybrid teaching, goal grading, project-driven step-by-step teaching model", "mutual assistance and progress, industry-education integration, broad, specialized, integrated practical education model", and "stage testing, systematic evaluation, whole-process diversified multi-level evaluation system" have been formed. The results show that this model effectively enhances students' autonomous learning ability, innovative awareness, and engineering practice ability. The achievement rate of course objectives, excellence rates, and pass rates have steadily increased year by year, with significant student innovation achievements. The course reform outcomes have received recognition from Shanxi Provincial Department of Education as an outstanding course and possess promotion value.

1. Introduction

New Engineering is a higher education development strategy proposed in response to the new round of scientific and technological revolution and industrial transformation, aiming to cultivate high-quality engineering talents with cross-border integration capabilities, innovation, practical abilities, and global perspectives[1]. As an important foundation supporting the construction of new engineering, computer fundamental courses bear the important task of cultivating students' computational thinking, programming skills, problem-solving abilities, and engineering literacy. Documents such as the "Declaration of Computer Teaching Reform" issued by the Teaching Steering Committee of University Computer Courses of the Ministry of Education and the "Joint Statement on Development Strategy of Computer Fundamental Teaching in C9 Universities" clearly point out that efforts should be made to strengthen the cultivation of college students' computational thinking abilities and regard them as one of the core objectives of computer fundamental courses[2].

However, current university computer fundamental courses still face many challenges. Firstly, the teaching mode is single and lacks flexibility, making it difficult to adapt to the different foundational levels of students. Secondly, the teaching content lags behind social demands, with outdated cases lacking frontier and interdisciplinary integration, leading to difficulties for students in applying learned knowledge to solve real-world problems. Thirdly, practical sessions are dependent on theoretical teaching, lacking systematicity and comprehensiveness, which hinders students from comprehensively applying their knowledge when facing complex engineering problems. Lastly, the evaluation method is singular, focusing more on results than processes, making it difficult to fully reflect students' learning effectiveness and developmental potential. These issues severely affect the quality of course instruction and constrain the enhancement of students' overall qualities and innovative capabilities[3-8].

Therefore, this study takes the "C Programming Language" course as a pilot, combining the OBE (Outcome-Based Education) philosophy to explore and construct a new hybrid teaching model for computer fundamental courses under the background of new engineering. By reconstructing teaching content, innovating teaching methods, building teaching resources, and optimizing evaluation mechanisms through multiple dimensions of reform, it aims to achieve the transition from "teacher-centered" to "student-centered", promoting high-quality course development and serving the talent cultivation goals of new engineering.

2. Current Situation and Pain Points Analysis of Courses

2.1 Single Teaching Mode, Restricted Personalized Development

Currently, most universities' computer fundamental courses still adopt the traditional "teacher lecture + classroom exercises + final exam" model, lacking differentiated teaching strategies for students at different foundational levels. Due to uneven popularization of computer education during primary and secondary school stages, freshmen's computer proficiency varies widely upon entry. Some students struggle due to weak foundations, while others lack motivation because the content is too simple. Additionally, classroom teaching focuses mainly on teacher explanations, resulting in low student participation and difficulty in stimulating active learning interest.

2.2 Lagging Teaching Content, Disconnected from Social Needs

Existing computer fundamental courses primarily focus on mathematical problem-solving, lacking integration with real-world application scenarios and cutting-edge technologies, making it challenging for students to apply what they learn to actual problem-solving. For example, the "C Programming Language" course extensively uses classic cases involving mathematical formulas and algorithm verification but involves little in emerging fields like data processing, artificial intelligence, and the Internet of Things, failing to meet the requirements for cultivating interdisciplinary composite talents under the background of new engineering.

2.3 Weak Practical Sessions, Insufficient Innovation Ability

Traditional experimental teaching content depends on theoretical teaching, with relatively simple experimental projects lacking comprehensiveness, innovation, and interdisciplinary characteristics. Students find it difficult to systematically analyze and solve complex engineering problems. Moreover, practical teaching lacks deep integration with enterprises and research projects, hindering the stimulation of students' innovative awareness and teamwork spirit.

2.4 Singular Evaluation Mechanism, Limited Feedback Effectiveness

Most courses still use final exams as the main form of summative assessment, neglecting attention to the learning process. This evaluation method fails to fully reflect students' learning behaviors, attitudes, emotional changes, and phased progress, hindering self-reflection and continuous improvement.

3. Teaching Reform Design Scheme

This teaching reform focuses on the goals of "value shaping, personalized development, thinking training, and professional integration", conducting comprehensive reforms around four core elements: teaching methods, teaching models, teaching content, and teaching evaluations, constructing a new curriculum system that is scientific, systematic, and dynamic, as shown in Fig. 1.

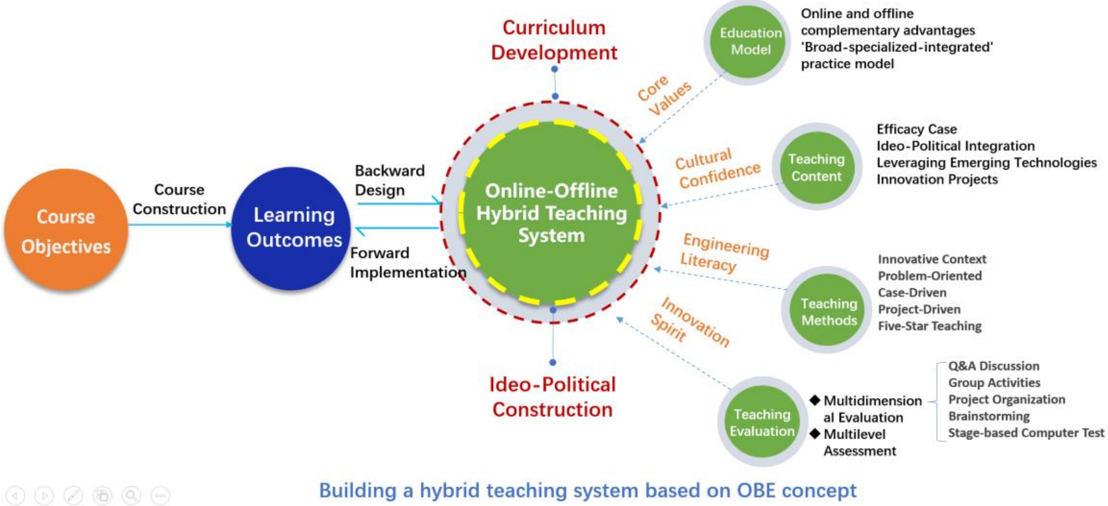

Figure 1. Instructional Reform Design Framework

3.1 Teaching Methods: Core Focus on OBE Philosophy, Strengthening Outcome Orientation

The course reform is based on the OBE philosophy, emphasizing "student-centeredness" and focusing on the visualization and measurability of learning outcomes. Through project-based learning (PBL), task-driven and project-driven approaches, students are guided to conduct exploratory learning in real-world problem contexts, enhancing their problem analysis and resolution capabilities.

3.2 Teaching Models: Online-Offline Integration, Building Multi-Level Learning Channels

A hybrid online-offline teaching model is constructed based on the principle of 'basic online, deepening in class, improving through practice, which offers diverse learning paths for students. Online platforms offer rich micro-lecture videos, online tests, interactive discussion areas, and other resources to support students' self-study; offline classrooms emphasize teacher-student interactions, deepen understanding and application through case analysis, group discussions, and project presentations, complementing each other to enhance overall learning efficiency.

3.3 Teaching Content: Case-Driven Reconstruction, Serving the Entire Teaching Process

Course content centers on cultivating students' computational thinking, using a case-driven approach to organize teaching, covering core knowledge points. Efficiency-enhancing innovative cases run throughout the course, breaking down complex knowledge points into easy-to-understand modules, enabling students to master knowledge through practice. The four-tier pedagogical progression, which encompasses basic cases, extended cases, integrated cases, and ideopolitical cases, facilitates the transformation from knowledge impartation to competency development, ultimately achieving value internalization.

3.4 Teaching Evaluations: Diversified Multi-Level, Promoting Comprehensive Student Development

Establishing a diversified, multi-dimensional evaluation system covering various aspects such as knowledge, ability, quality, and emotion. Evaluation subjects include peer assessments, teacher evaluations, and system automatic evaluations, with evaluation methods combining formative and summative assessments. Through three-stage machine tests, experimental project evaluations, learning behavior records, and other methods, the system focuses on students' learning processes and phased achievements, helping them adjust their learning strategies for continuous improvement.

4. Implementation Pathways and Teaching Innovation Features

4.1 Hierarchical Learning Objectives: Three-Level Objective Conversion, Precise Positioning of Learning Paths

Course objectives are refined into unit objectives and specific knowledge point objectives, forming a three-level objective system of "course objectives - unit objectives - knowledge point objectives". Each level corresponds to different learning tasks and evaluation standards, ensuring that students can set reasonable learning goals based on their own circumstances, gradually achieving the leap from basic knowledge to advanced capabilities.

4.2 Hierarchical Learning Channels: Complementarity Between Online and Offline, Meeting Diverse Learning Needs

Through the hybrid teaching model, constructing a learning path of "basic online, deepening in class, improving through practice". Online resources support students in previewing, reviewing, and filling gaps, while offline classrooms focus on in-depth explanations, case analyses, and project practices, complementing each other to enhance overall learning efficiency.

4.3 Hierarchical Teaching Content: Four-Tier Case-Driven Approach, Achieving Tiered Capability Enhancement

Teaching content is divided into four tiers: basic cases, extended cases, integrated cases, and efficiency cases, corresponding to knowledge objectives, capability objectives, advanced objectives, and value objectives. Taking "aviation voice recognition" as an example, centering around the core knowledge point of multi-branch selection structures, guiding students to complete the entire process from problem abstraction, algorithm design to code implementation, enhancing their logical thinking and engineering practice capabilities.

4.4 Hierarchical Experimental Practices: Constructing a Broad, Specialized, Integrated Practical Education Model

Experimental teaching breaks away from the traditional dependency on theoretical teaching, constructing a broad, specialized, integrated practical education model:

Basic Experiments: Train students' basic knowledge application abilities;

Comprehensive Experiments: Enhance students' abilities to comprehensively apply knowledge to solve complex problems;

Innovative Experiments: Encourage students to engage in scientific and technological innovation activities based on their professional backgrounds through industry-academia cooperation projects.

Additionally, the course team builds a "mentorship" tutoring mechanism, led by excellent teachers, selecting outstanding students as teaching assistants, forming a collaborative model of "1 teacher - 6 teaching assistants - 2 groups - 6 members", ensuring the quality of practical teaching segments.

4.5 Hierarchical Evaluation Methods: Whole-Process Diversified Multi-Level Evaluation System

Constructing a diversified multi-level evaluation system primarily based on formative assessment supplemented by summative assessment, covering various dimensions such as knowledge, ability, quality, and emotion. Evaluation subjects include peer evaluations, teacher evaluations, and system automatic evaluations. Through three-stage machine tests, experimental project evaluations, learning behavior records, etc., helping students promptly adjust learning strategies to achieve continuous improvement.

5. Teaching Achievements and Promotion of Results

5.1 Steady Improvement in Academic Performance

Data from the past three years shows that the achievement rate of course objectives, excellence rates, and pass rates have shown a steady upward trend. Taking students from the College of Science as an example, in 2023 compared to 2022, the excellence rate increased by 18.32%, with a 100% completion rate for project designs, a 96% pass rate, and an excellence rate of 30%.

5.2 Significant Enhancement in Students' Innovative Abilities

Course reform has stimulated students' strong interest and innovative awareness, with multiple student teams winning awards in national college student innovation and entrepreneurship competitions, provincial programming competitions, etc. Students spontaneously form innovation teams, establish innovation laboratories, actively participate in various scientific research and engineering projects, fostering a good innovative atmosphere.

5.3 Course Achievements Recognized at the Provincial Level

The course won first prize in the provincial ideological and political teaching competition in 2023 and was successfully recognized as a provincial-level outstanding course in 2024. The course team teachers have repeatedly been awarded titles such as "Favorite Teacher Among Students" and have received multiple honors as outstanding mentors in college student innovation and entrepreneurship projects.

5.4 Promotion and Demonstration Effects of Results

The experience of course reform has been adopted and applied in several universities. The course team has been invited multiple times to share reform experiences at teaching seminars, with relevant teaching models and evaluation systems being introduced into the teaching practices of computer fundamental courses in multiple institutions. In the future, the course team will continue to deepen teaching reform, further optimize the curriculum system, improve teaching quality and talent cultivation levels, providing continuous impetus for the innovative development of computer fundamental education in universities.

6. Conclusion and Outlook

This paper takes the "C Programming Language" course as a pilot, exploring and constructing a new hybrid teaching model for computer fundamental courses under the background of new engineering. Through hierarchical objectives, content reconstruction, practical promotion, evaluation optimization, and other multidimensional reforms, the course has achieved the transition from "teacher-centered" to "student-centered", effectively enhancing students' enthusiasm for learning, practical abilities, and innovative awareness.

In the future, the course team will continue to deepen research and practice in the following directions:

- Enhancing the connotation and extension of the course: Timely absorbing the latest achievements in the field of computers, updating teaching content to ensure close integration between theory and practice.
- Optimizing the hybrid teaching model: Exploring more efficient online-offline integration strategies to leverage respective advantages and enhance teaching effectiveness.
- Building stereoscopic textbooks and digital resources: Developing integrated designed, multimedia-fused stereoscopic textbooks and establishing a dynamic update mechanism.
- Promoting AI-assisted teaching and smart course iMOOC construction: Utilizing artificial intelligence technology to assist teaching design, personalized learning path planning, and inquiry-based learning guidance to promote students' learning experiences and self-growth.
- Improving the evaluation system: Adding more dimensions and perspectives to the evaluation, focusing on knowledge, ability, quality, emotion, and participation degree, among other non-cognitive factors, to promote comprehensive development.
- The course reform provides valuable experiences and demonstrations for the innovative teaching of computer fundamental courses in universities, possessing strong promotion value and practical significance.

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References

[1] Wu Yuxin, Ji Xinyan. Design-oriented Programming Teaching for Cultivating Computational Thinking[J]. Computer Education, 2023, (12): 331-335+340.

[2] Li Juan, Zhou Huatao, Chen Yuan. Research on Computer Fundamental Education Reform Under the Background of New Engineering[J]. Technology Wind, 2022(7): 112-114.

[3] Ye Xiaoxia, Peng Xiaohong, Yu Yinghuai. Exploration of Integration Pathways Between Hybrid Teaching and Ideological and Political Education in Operating Systems Courses[J]. Computer Education, 2023(6): 103-108.

[4] Liu Jinyue, Shi Guiying, Zhu Baodong. Research and Practice on a Diversified Ideological and Political System for "University Computer Fundamentals" from the Perspective of Holistic Education[J]. Industry and Information Education, 2022(5): 36-39.

[5] Gui Xiaolin, Wu Fuying, Yi Yugeng. Practice of Blended Teaching Model Integrating Theory and Practice in Linux Foundation Courses Under the Background of Curriculum Ideology and Politics[J]. Computer Education, 2021(9): 1-5.

[6] Wang Xuemei, Hu Sujun, Li Peng. Exploration and Practice of Ideological and Political Teaching in Computer Network Courses [J]. Computer Education, 2021(9): 19-22.

[7] Zhu Zhengzhou, Zhong Jiang. Construction of Ideological and Political Education in Software Engineering Courses Combining Theory and Practice[J]. Computer Education, 2021(9): 23-26.

[8] Gao Yan, Lin Ying, Wu Dewen. Exploration of Project-Driven Online-Offline Heuristic Deep Learning Practical Teaching[J]. Computer Education, 2021(9): 51-53.