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Construction and Practice of an AI-Empowered OBE Precision Teaching System for Engineering Courses Oriented to Heterogeneous Learning Profiles

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Abstract: *To address the long-standing pain points of engineering fundamental courses in academic continuing education, namely the disconnection between teaching objectives and training specifications, the insufficient supply of personalized instruction, the weakening of practical components and the monotony of assessment, this study constructs an AI-empowered OBE precision teaching system. Taking the course Circuit Principles as the carrier, the Outcome-Based Education (OBE) concept is integrated into the whole process of curriculum design through backward design, while artificial intelligence is deployed to achieve precise learner profiling, stratified resource delivery, virtual-physical integrated practice and intelligent closed-loop evaluation. The learner heterogeneity caused jointly by professional foundation, career needs and learning time preference is defined as the logical starting point of teaching design. After two rounds of teaching practice, the course pass rate rose from the baseline of 65% to 82% and the excellence rate (≥85 points) from 10% to 32%; satisfaction with the effect of ideological and political education, with the AI question-answering robot and with on-the-job competency reached 91%, 87% and 86% respectively. The results indicate that the system improves students' outcome attainment and teaching satisfaction, and provides an implementable paradigm for guaranteeing the same quality of continuing education as that of full-time programs. The proposed method chain can be further extended to undergraduate courses, postgraduate courses and the integrated development of undergraduate-postgraduate curricula.*

Keywords: *Artificial Intelligence, OBE Concept, Continuing Education, Precision Teaching, Heterogeneous Learning Profiles, Circuit Principles*

1. Introduction

Academic continuing education in higher education plays an important role in cultivating applied talents [1]. The Implementation Opinions on Promoting the Reform of Academic Continuing Education in Regular Institutions of Higher Education in the New Era (No. 2 [2022] of the Department of Vocational and Adult Education), issued by the Ministry of Education, explicitly requires that the same standard and the same quality of talent cultivation be maintained [2]. In engineering courses of traditional continuing education, however, a four-fold disconnection has long existed. First, teaching objectives are disconnected from talent training specifications, which makes it difficult to implement Outcome-Based Education (OBE), a paradigm in which curriculum design is driven backwards from the learning outcomes that students are expected to ultimately demonstrate [3]. Second, teaching provision is disconnected from student characteristics: the personalized needs of adult in-service students, who are characterized by a prominent conflict between work and study commitments, large differences in learning foundation and a clear career orientation, can hardly be satisfied. In this paper, the above differences jointly caused by professional foundation, career needs and learning time preference are summarized as the heterogeneity of learning profiles, which is taken as the logical starting point of teaching design. Third, theoretical teaching is disconnected from engineering practice, and practical components are seriously weakened under multiple constraints of time, space and resources. Fourth, assessment methods are disconnected from outcome attainment: a single final examination cannot capture the growth of engineering ability, and the feedback loop for continuous improvement is absent.

Meanwhile, the educational application of artificial intelligence offers new possibilities for resolving these dilemmas. Nevertheless, existing AI-in-education studies focus predominantly on full-time undergraduate contexts [4,5]; although explorations in continuing education have begun [6], systematic and implementable AI-and-OBE teaching paradigms remain scarce. It is this gap that the present study

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addresses. The University of Shanghai for Science and Technology offers this course as a compulsory professional fundamental course in the Electrical Engineering and Automation program, a junior-college-to-university upgrading program. The course is highly theoretical and practice-intensive, serving as the hub connecting preceding mathematics and physics courses with subsequent core professional courses. Taking this course as the implementation carrier, this paper systematically expounds the construction logic, innovative model and implementation path of an AI-empowered OBE precision teaching system, aiming to provide a replicable and promotable practical sample for the teaching reform of engineering fundamental courses in continuing education. It should be noted that the author has previously explored the integration of AI and OBE in the course Engineering Electromagnetic Fields [7]. The present study differs from that work in research object, learner characteristics, teaching model and empirical data, and constitutes an independent construction and extension of the method chain in the continuing education scenario.

2. Conceptual Innovation: Constructing a Teaching Paradigm of OBE Top-Level Orientation and AI Full-Process Empowerment

2.1. Backward Design: A Curriculum Support Matrix Anchored by Training Objectives

Traditional teaching mostly adopts the forward design logic of knowledge transmission, which leads to a vague mapping between course objectives and the indicators of graduation requirements. This study takes the training objective of cultivating versatile high-level engineering and technical talents in the electrical engineering field as the top-level anchor. Drawing on the outcome-based implementation path of engineering education accreditation [8], it decomposes the supporting relationship between Circuit Principles and the twelve graduation requirement indicators in a backward manner, and constructs a visualized course objective–graduation requirement support matrix. The course objectives are refined into three-dimensional measurable indicators, namely knowledge (depth of circuit theory), ability (intensity of engineering practice) and quality (height of professional literacy, including ideological and political elements such as craftsmanship and safety norms). The support weight and attainment threshold of each indicator are specified, so that the contribution of the course can be traced quantitatively.

2.2. AI Empowerment: From Auxiliary Tool to Teaching Paradigm Reconstruction

Existing AI applications in education mostly remain tool-oriented, such as simple courseware generation or online question answering. This study positions AI as the core driving force of teaching paradigm reconstruction, embedding it deeply into the whole chain of objective design, learning diagnosis, resource delivery, teaching implementation, practice training, evaluation feedback and continuous improvement. Through the coordination of the AI learning diagnosis system, the intelligent question-answering robot, the virtual simulation platform and the outcome attainment analysis system, a new teaching ecosystem featuring data-driven decision-making, intelligent precision adaptation and closed-loop continuous optimization is formed, which truly implements the OBE core concept of being student-centered and outcome-oriented. The overall framework of the system is shown in Figure 1.

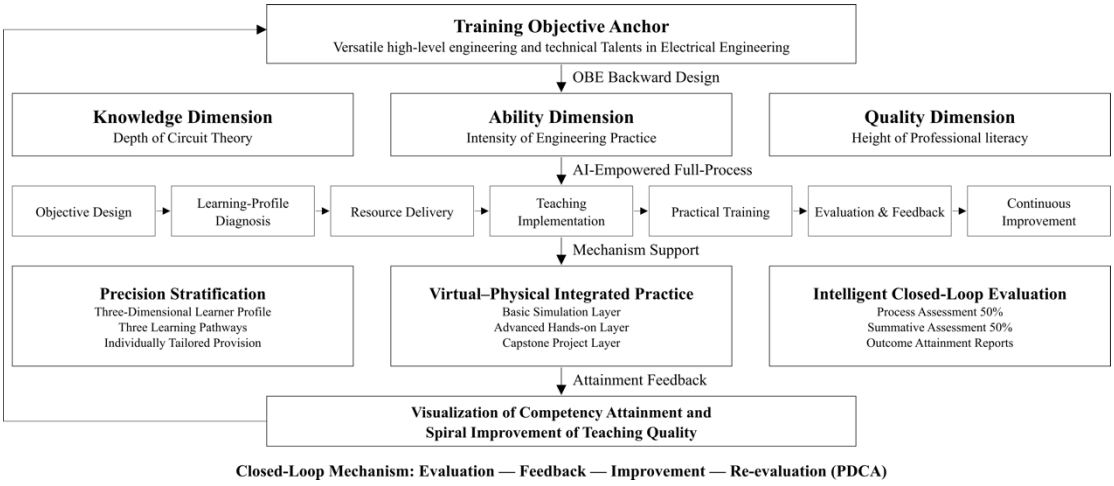


Figure 1: Overall framework of the AI-empowered OBE precision teaching system.

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3. Model Innovation: A Blended Teaching System of Precision Stratification, Virtual-physical Integration and Career Orientation

3.1. AI Precision Profiling and Stratified Resource Delivery

Considering that adult in-service students differ greatly in foundation and suffer from fragmented time, an AI learning diagnosis system adapted to the continuing education scenario is developed. Students build a three-dimensional profile of professional foundation, career needs and learning time preference through a ten-to-fifteen-minute pre-test on mobile terminals. Based on the profiling results, three types of stratified learning paths are intelligently delivered: the foundation-remedial type, which provides prerequisite micro-lectures, a basic exercise bank and learning reminders; the consolidation-and-improvement type, which provides breakthroughs in key and difficult points, comprehensive case analysis and extended reading; and the career-advancement type, which provides industry frontier technologies, advanced simulation projects and alignment with professional qualification requirements. In addition, the granularity of the delivered resources is adapted to each student's learning time preference: ten-to-fifteen-minute micro-lectures are pushed to those who study in fragmented time slots, whereas complete case packages are provided to those with longer available periods. This model breaks through the limitations of the traditional one-size-fits-all teaching and delivers personalized teaching provision for every learner.

3.2. Blended Mode of Online Live Lecturing and Offline Case Seminar

The online component, which accounts for 80% of the class hours, relies on the Multisim virtual simulation platform to present key and difficult points visually, and uses AI real-time interaction tools, including real-time on-screen commenting analysis, in-class quizzes and affective computing, to obtain instant feedback on classroom learning status so as to adjust the teaching pace dynamically. The offline component, which accounts for 20% of the class hours and strictly complies with the regulations of the Ministry of Education, consists of two weekend intensive sessions that focus on engineering case seminars and hands-on training, thereby alleviating the shortage of concentrated learning time for in-service students. Meanwhile, an AI teaching assistant is deployed to answer students' questions in real time, which relieves the pressure caused by the insufficient teacher-student ratio in continuing education classrooms.

3.3. Three-Stage Virtual-physical Integrated Engineering Practice System

A three-stage progressive practice system is constructed, comprising a basic simulation layer, an advanced hands-on layer and a capstone project layer. The basic simulation layer relies on the AI-driven Multisim virtual simulation platform, which intelligently guides experimental procedures, automatically diagnoses connection errors and generates experiment report templates, covering all basic experiment requirements of the course and breaking through the constraints of time and space. The advanced hands-on layer introduces circuit design and verification in real engineering scenarios of the power industry, and accomplishes parameter optimization and scheme recommendation with AI-aided design tools. The capstone project layer connects with real engineering cases of power enterprises in the Yangtze River Delta, such as distribution design of smart grids and optimization of new-energy grid-connection circuits; task decomposition, progress tracking and collaboration support are supported by the AI project management system, and industry experts are invited to provide remote guidance. The three-stage system satisfies the fragmented and mobile learning needs of adult students, while strictly implementing the rigid requirements of the training program regarding offline practice hours.

3.4. Career-Oriented Industry-Education Integration Mechanism

The course integrates the training content of the "1+X" certificate system, which comprises one academic diploma plus several vocational skill certificates, such as the low-voltage electrical operation certificate and the professional qualification certificate for electrical engineers. Course content is thereby aligned with certificate requirements, achieving course–certificate integration. Practical teaching bases are jointly established with the Training Center of State Grid Shanghai Municipal Electric Power Company and the Education and Training Center of Shanghai Electric Group, and three to five industry experts are invited to participate in case development and practice guidance. Theoretical knowledge is thus deeply coupled with practical cases of power engineering, enabling students to accomplish systematic ability cultivation within fragmented learning, which is precisely consistent with the principle

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of learning for practical application.

4. Evaluation Innovation: An Intelligent Closed-Loop Evaluation System with Quantified Outcome Attainment and Continuous Teaching Improvement

4.1. Restructuring the Assessment Structure and Strengthening Process Evaluation

Moving beyond the traditional single-examination mode, the weight of process assessment is raised to 50%; this consists of pre-class preview based on AI learning behavior data (10%), in-class interaction based on AI participation analysis (10%), after-class homework and AI question answering evaluated by completion and quality (10%), simulation training scored automatically by AI (10%), and project practice evaluated comprehensively by industry experts and AI (10%). The summative assessment accounts for 50% and adopts a closed-book examination, which complies with the provision of the training program that the final examination score accounts for 40% to 80% of the total score. This structure not only safeguards the normative requirements but also comprehensively reflects the trajectory of students' ability growth; the observation content, AI support mode and weight allocation of each assessment component are given in Table 1.

Table 1: Structure and weight allocation of course assessment.

Assessment component	Observation content	AI support mode	Weight	Assessment type
Pre-class preview	Learning behavior data (video watching duration, replay frequency)	Automatic collection by learning analytics	10%	Process assessment
In-class interaction	Classroom participation (bullet-screen messages, in-class quiz data)	AI real-time interaction analysis tool	10%	Process assessment
After-class homework and AI Q&A	Homework completion and answer quality	AI automatic marking and intelligent Q&A	10%	Process assessment
Simulation training	Virtual experiment design and data analysis	Intelligent scoring based on evaluation rubrics	10%	Process assessment
Project practice	Completion quality of engineering case schemes	Comprehensive evaluation by industry experts and AI	10%	Process assessment
Final examination	Comprehensive mastery of circuit theory	Closed-book examination (manual marking)	50%	Summative assessment
Total	—	—	**100%**	—

4.2. AI-Empowered Multi-Dimensional Quantitative Evaluation

Four measures are implemented. First, objective questions are marked automatically: AI instantly completes the marking of multiple-choice, fill-in-the-blank and true-or-false questions and gives feedback. Second, simulation experiments are evaluated intelligently: based on the preset evaluation rubric, AI conducts multi-dimensional quantitative scoring of experimental design, data analysis and conclusion derivation. Third, learning behavior is analyzed in depth: learning analytics technology is used to track all data such as video watching duration, pause and replay frequency, number of exercise attempts and intensity of community interaction, thereby constructing students' digital learner profiles. Fourth, outcome attainment reports are generated automatically: individual and class reports are produced to clearly present the attainment of the course with respect to the twelve graduation requirement indicators and to visualize the trajectory of students' ability growth.

4.3. PDCA Dynamic Closed Loop and Continuous Improvement

In this study, a closed-loop mechanism of evaluation, feedback, improvement and re-evaluation is established following the PDCA cycle [9]. At the end of each semester, a teaching reflection meeting is held on the basis of the overall outcome attainment data of the class, so as to optimize teaching content, teaching methods and resource supply dynamically. Through AI full-cycle data collection, the spiral improvement of teaching quality is achieved, which provides data support and a decision-making basis for the quality assurance of continuing education.

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5. Practice Effectiveness, Promotion Value and Outputs

5.1. Significant Improvement in Students' Outcome Attainment

After two rounds of teaching practice, the course pass rate increased from the previous baseline of 65% to 82%, and the excellence rate, defined as a score of no less than 85 points, increased from 10% to 32%. Students' satisfaction with the effect of ideological and political education reached 91%. The AI question-answering robot was used 3.2 times per week on average, with a satisfaction rate of 87%. Feedback from employers indicates that students' ability to apply the knowledge of Circuit Principles to workplace practice has improved, and satisfaction with on-the-job competency reached 86%.

5.2. Formation of a Replicable Teaching Reform Paradigm

The OBE and AI teaching system, the stratified teaching model and the intelligent evaluation system formed in this project can be directly transferred to professional fundamental and core courses such as Power Electronics Technology and Power Supply and Distribution Technology, thereby driving the overall improvement of teaching quality in the continuing education of the electrical engineering and automation program. Meanwhile, this paradigm provides a pioneering practical sample for the implementation of the policy of empowering education with artificial intelligence in the field of continuing education, and produces favorable demonstration and spillover effects.

5.3. Extension Pathways to Undergraduate Courses, Postgraduate Courses and Integrated Undergraduate-Postgraduate Curriculum Development

The method chain of learning profiling, stratified delivery, virtual-physical integration and closed-loop evaluation formed in this study is adaptable across educational stages. Its value lies not in the simple translation of the paradigm, but in the reverse output of the stratified adaptation and process closed-loop mechanism that has been validated under the extremely heterogeneous learning profiles of continuing education. For undergraduate courses, such as Circuit Principles and Engineering Electromagnetic Fields offered at the undergraduate level, AI learning diagnosis and whole-process data governance can be relied upon to achieve large-scale personalized supply under large-class conditions, focusing on solving the problems of large differences in foundation and the difficulty of tracking the learning process. For postgraduate courses, such as Plasma Technology and Applications, the focus of AI empowerment shifts from the attainment of knowledge points to the attainment of research ability: disciplinary knowledge graphs and simulation-based deduction support literature reading, scheme design and evaluation of innovativeness, serving the cultivation of postgraduates' independent research ability. For the integrated development of undergraduate-postgraduate curricula, an articulated course objective matrix together with a shared knowledge graph serves as the link to break through the curriculum boundary between the senior undergraduate stage and the postgraduate stage, realizing the cross-stage continuity of learning-profile data, the continuous tracking of outcome attainment and the mutual recognition of credits, thus forming a course-group paradigm of integrated design, staged attainment and continuous evaluation. The extension at all three levels is built on the common basis of the OBE attainment evaluation closed loop of this study, and the difference lies only in the stage-specific adaptation of data granularity and evaluation indicators.

5.4. Outputs and Brand Effects

During the implementation period of the project, the team built one university-level "excellent online course" for continuing education, developed one AI learning diagnosis system and one intelligent question-answering robot, and produced standardized syllabi, lesson plans and three types of stratified teaching resource packages. Two teaching reform papers were published and one university-level teaching achievement award was obtained, providing solid theoretical and practical support for the substantive and high-quality development of continuing education.

6. Conclusions

The deep integration of artificial intelligence and the OBE concept provides a systematic solution for resolving the teaching difficulties of engineering courses in continuing education. Taking Circuit Principles as the carrier, this study constructs a precision teaching system integrating concept, model and

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evaluation, and realizes the paradigm transformation from knowledge transmission to outcome attainment, from uniform teaching to precision adaptation, and from result assessment to process closed loop. The two rounds of practice indicate that this system is workable and effective, and can provide reference for the teaching reform of engineering fundamental courses in continuing education at similar institutions. Future research can further explore the in-depth application of large language models in personalized tutoring, the intelligent construction of cross-course knowledge graphs, and the migration verification of this method chain in undergraduate courses, postgraduate courses and integrated undergraduate-postgraduate curriculum development, so as to continuously promote the precision construction of electrical engineering programs.

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