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Reform and Practice of Teaching Design for the Fundamentals of Artificial Intelligence Course Based on the OBE Concept

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Abstract: This paper presents an OBE (outcome-based education) oriented teaching design reform of the undergraduate course entiled Fundamentals of Artificial Intelligence, which is typically offered to students majoring in automation, computer science, electronic engineering, and related interdisciplinary programs. Departing from the traditional textbook-driven, teacher-centered delivery model, the reform is structured around four core OBE links: (i) reverse design of course objectives mapped to graduation requirement indicators; (ii) modular reconstruction of teaching content covering AI foundations, machine learning, natural language processing, computer vision, and AI ethics integrated with contextualized projects; (iii) project-based and inquiry-driven instructional activities; and (iv) diversified formative assessment with a course-objective–assessment mapping matrix. The findings suggest that OBE-based reverse design, modular content organization, and process-oriented assessment effectively promote students' algorithmic comprehension, practical problem-solving ability, and learning engagement in AI foundational education.

Keywords: OBE concept; Fundamentals of Artificial Intelligence; teaching design; teaching reform

1. Introduction

With the rapid penetration of artificial intelligence technologies across all sectors of society, higher engineering education is facing mounting pressure to cultivate graduates who not only understand AI concepts but can also apply AI methods to solve domain-specific problems[1]. The course Fundamentals of Artificial Intelligence serves as a core compulsory or elective course for undergraduates in computer science, automation, electronic information, and related engineering disciplines. It is expected to lay a foundation for students' subsequent engagement with intelligent systems, machine learning applications, and interdisciplinary AI-empowered innovation. However, traditional delivery of this course in many institutions still follows a chapter-by-chapter exposition of textbook content, over-emphasizes formula derivation, and relies predominantly on a single terminal examination to judge learning outcomes[2].

The Outcome-Based Education (OBE) philosophy, endorsed by major engineering education accreditation frameworks, advocates beginning with clearly defined intended learning outcomes aligned with graduation requirements, and then aligning all curricular elements, namely syllabus design, instructional strategies, learning resources, and assessment instruments, to support the achievement of those outcomes[3]. Applying OBE to a fast-evolving, practice-intensive course such as Fundamentals of Artificial Intelligence poses distinctive opportunities as well as challenges[4].Against this backdrop, this paper reports on a systematic OBE-based teaching design reform of the Fundamentals of Artificial Intelligence course.

2. OBE-Based Teaching Design Reform of the Fundamentals of Artificial Intelligence Course

2.1. Outcome-oriented Course Objective Design

Based on the OBE concept, the teaching reform of Fundamentals of Artificial Intelligence profoundly subverts the traditional cramming education model[5]. The first step is to reset teaching goals through backward (reverse) design of the course syllabus. Educators are required to break away from the rigid constraints of textbooks and start from the engineering capabilities and generic qualities students should possess upon graduation, as specified by program-level graduation requirement indicators aligned with engineering accreditation criteria, and then reverse-engineer the teaching content, workload, and assessment methods accordingly.

For example, when the Department of Electrical Engineering at Guangxi University reworked the syllabus of Fundamentals of Artificial Intelligence for automation-major students, the redesign was fully anchored on the OBE concept. The faculty first interpreted the graduation requirement indicators, and under their guidance, reverse-engineered the teaching content as theory plus competition practice, which helped address the mismatch between teaching content and industry needs. Course objectives were articulated using measurable action verbs derived from Bloom's Taxonomy, and a course-objective-to-graduation-requirement mapping matrix was established. This ensures that teaching is not a random acquisition of information but a deliberate process of constructing the vessel upon which students will later sail in their professional careers[6].

2.2. Modular Reconstruction of Teaching Content

Regarding teaching materials, the reform focuses on fragmenting and reorganizing traditional chapters into a modular structure that incorporates recent technological advances. According to the OBE philosophy, The introduction to Artificial Intelligence course offered to all freshmen at Chongqing Jiaotong University was redesigned into five modules: AI Foundations , Machine Learning Basics, Natural Language Processing, Computer Vision, and AI Ethics and Applications[7].Such a modular reorganization prevents students from being discouraged by arid theory alone; instead, they gradually gain expertise in mastering the technology through authentic examples. This modular architecture, which integrates state-of-the-art technologies with realistic situations, not only increases students' interest in studying but also develops their problem-solving skills based on cross-disciplinary integration, which fits the central requirements of the OBE philosophy exactly.

2.3. Project-Based and Inquiry-Based Teaching Activities

Teaching method innovation aims at heuristic inquiry, which fully engages students' innovative thinking. Case-driven and project-based inquiry is gaining popularity over conventional theoretical lectures[8]. For instance, teachers may abandon the rote derivation of formulas in the NLP section of Fundamentals of Artificial Intelligence and instead pose an exciting inquiry task: designing an Automatic Poetry-Writing Robot. To accomplish this task, students must actively investigate complex logics such as recurrent neural networks (RNNs/LSTMs) and preprocess text corpora. This learning-by-doing inquiry environment maximally stimulates the innovative potential and subjective initiative of students, enabling them not merely to comprehend the generation logic of AI but also to apply skills in literature retrieval, data processing, and algorithm debugging, thereby realizing the internalization and reconstruction of knowledge. Each project is explicitly mapped to the corresponding course objective, ensuring alignment between activities and expected outcomes.

2.4. Diversified and Formative Assessment Design

Traditional assessment of Fundamentals of Artificial Intelligence heavily relies on a single terminal examination, which merely tests rote memorization of isolated concepts such as search algorithms or logical inference rules, but fails to reflect students' competence in applying AI techniques to solve real-world problems. Under the OBE paradigm, assessment must shift from testing what was taught to evidencing what was learned, that is, the attainment of predefined course objectives. A multi-dimensional, process-oriented assessment system is therefore established. Specifically, the final grade is decomposed into multiple weighted components, each mapped to specific course objectives:

(1) Regular coursework and online quizzes (15%) assess mastery of foundational knowledge through spaced retrieval tasks on the LMS;

(2) Classroom participation and in-class discussion or ethical debate (10%) evaluate engagement in case analysis and AI ethics discussions, reflecting attainment of generic or soft-skill objectives;

(3) Laboratory reports (25%) require students to implement classical algorithms and analyze experimental results, examining their ability to use modern AI tools and interpret model behavior;

(4) Project-based inquiry task with oral defense or presentation (20%) requires teams to complete a mini-project and present their design rationale, data preprocessing, and limitation analysis, which assesses problem-solving, teamwork, and communication skills;

(5) Final closed-book examination (30%) focuses on conceptual understanding and analytical reasoning across all modules to ensure comprehensive theoretical grounding.

Crucially, a course objective–assessment mapping matrix is constructed beforehand: each assessment component is tagged to one or more course objectives. After the course ends, the course objective attainment degree is calculated by averaging the normalized scores of assessment items linked to each objective. If the attainment value falls below the expected threshold (commonly 0.65–0.70), the course team conducts a root-cause analysis to identify weak instructional segments and adjusts the subsequent syllabus, thus closing the OBE continuous improvement loop. This diversified mechanism reduces the contingency of a single exam and provides transparent, traceable evidence of student learning outcomes.

3. Implementation Challenges of OBE-Based Teaching Design Reform

3.1. Difficulty in Translating OBE Concepts into Measurable Course Objectives

The lagging teaching concepts of some teachers and deeply ingrained traditional lecture habits constitute a primary difficulty in course reform. Some teachers have only a superficial understanding of the OBE concept and fail to internalize its core backward design thinking into actual teaching actions. In the traditional model, teachers are accustomed to teaching in the order of textbook chapters and consider completing the teaching schedule as the primary goal, while neglecting students' true ability output. To shift the mindset to begin with the end in mind requires teachers to restructure the knowledge system and invest considerable time in industry research to determine the real graduation requirement indicators. Moreover, the traditional one-way knowledge transmission model is deeply rooted, and teachers lack practical experience in guiding students to conduct independent exploration and project practice, making the OBE syllabus prone to becoming a formality on paper when implemented and failing to fundamentally change the classroom ecology. Compounding this, many teachers find it difficult to decompose abstract graduation requirements into specific, observable, and measurable course-level intended learning outcomes, and the mapping among course objectives, teaching activities, and evaluation indicators often remains vague.

3.2. Difficulty in Continuously Updating Modular Teaching Resources Amid Rapid AI Technology Iteration

The OBE concept emphasizes that teaching content must be closely aligned with cutting-edge technologies and industry demands. However, in reality, the publication cycle of textbooks is long, and the knowledge therein is highly static. By the time a book is published, some technical frameworks or industry application cases may already be outdated. Meanwhile, various open-source algorithm libraries, deep learning platforms, and development toolchains upgrade at a monthly pace. If teachers insist on dynamically integrating the latest technologies, they must spend a significant amount of time on self-study, selection, and reconstruction of teaching modules in addition to heavy teaching and research workloads. This not only increases teachers' burden but also makes carefully designed modular teaching content face the risk of secondary aging within just a few semesters, making it difficult to maintain the course's long-term vitality and cutting-edge nature.

3.3. Difficulty in Organizing Project-Based Learning for Students with Heterogeneous Foundations

In the context of promoting interdisciplinary and general education, the classroom may simultaneously have students with solid programming skills from computer science backgrounds and those lacking a foundation in advanced mathematics and coding from non-CS or even liberal arts backgrounds. For students with a foundation, inquiry-based teaching may seem slow and lack challenge; for those without a foundation, severe frustration may arise from not understanding the underlying algorithm logic, leading to loss of motivation. Teachers find it difficult to balance the depth of inquiry and project difficulty for students with different prior knowledge. How to provide personalized scaffolding guidance for students with different prior knowledge within a single physical space has become a pain point affecting the effectiveness of classroom interaction and the improvement of teaching quality.

3.4. Difficulty in Supporting Continuous Improvement with Reliable Assessment Data

The diversified assessment mechanism requires the evaluation focus to shift from the final exam to dynamic tracking throughout the process, which entails the regular collection of students' performance data in project iterations, team collaboration, experimental debugging, and other stages. However, traditional manual grading and Excel-based statistics cannot handle such voluminous and complex process information. Currently, most universities lack intelligent teaching process management platforms, making it difficult for teachers to capture the subtle trajectories of students' ability improvement. Without objective and continuous data as support, the so-called achievement evaluation of abilities often relies on teachers' subjective impressions for rough estimation. This not only weakens the persuasiveness of diversified assessment but also leaves subsequent teaching improvement lacking a precise target, thereby hindering the OBE-mandated continuous improvement cycle.

4. Improvement Strategies for OBE-Based Teaching Design Reform of the 、 Fundamentals of Artificial Intelligence Course

In response to the implementation challenges identified above, the reform of Fundamentals of Artificial

Intelligence should not be limited to isolated adjustments in teaching methods or assessment forms. Instead, a systematic improvement mechanism integrating teacher development, teaching resource construction, differentiated instruction, and data-driven assessment must be established, so as to strengthen the alignment among learning outcomes, teaching activities, assessment evidence, and continuous improvement.

4.1. Enhancing Teachers' Ability in OBE-Oriented Course Design

To counteract issues stemming from incomplete understanding of the OBE concept and hardened old teaching models, a stratified, categorized, and systematic training program should be created to renew teachers' conceptual understanding and change their teaching roles, ensuring genuine adoption of the OBE concept in classrooms.

First, invite OBE teaching reform experts and industry backbone engineers to deliver specialized seminars, deconstructing the essence of backward design and beginning with the end in mind, and using Fundamentals of Artificial Intelligence as a case to illustrate how to align course objectives with graduation requirement indicators, perform backward syllabus design, and construct a course-objective–assessment mapping matrix, addressing the common problem that teachers grasp the concept but do not know how to implement it. Second, establish inter-school and interdisciplinary teaching-research communities for collective lesson preparation and sharing of OBE reform experiences across institutions. Integrate OBE reform outcomes into the teacher performance appraisal framework and provide special incentives for reform participation. Additionally, arrange for teachers to undertake field studies in AI enterprises to learn current industry needs and application scenarios, and transform authentic industrial problems into instructional cases, guiding teachers to internalize the OBE concept into daily teaching acts rather than allowing reform to become mere formalism.

4.2. Constructing a Dynamically Updated Modular Teaching Resource System

To resolve the problem of teaching resources lagging behind technological iteration, a school-enterprise collaborative education mechanism should be utilized to build a dynamically updated, industry-aligned teaching resource library.

First, develop intensive cooperation with high-quality AI enterprises, sign collaborative education agreements, and form school-enterprise joint teaching teams. Corporate technical staff provide up-to-date technical documentation, industrial cases, development tools, and real project datasets, while faculty members refactor them into modularized course content. Establish a regular resource-review cycle during which the school-enterprise team scans and updates teaching cases, experimental projects, and courseware, adding content on generative AI, embodied intelligence, and digital twins while retiring obsolete frameworks, to keep materials current. Develop school-based textbooks and practical guides that embed modular content according to course goals and industry requirements, supplementing traditional static textbooks. Concurrently, leverage MOOCs, open-source platforms, and virtual simulation experiment systems to reduce the individual burden on teachers of independently maintaining resources, while offering students self-paced learning pathways. This co-construction, sharing, and dynamic optimization mechanism helps ensure the course's long-term vitality.

4.3. Implementing Differentiated and Scaffolded Teaching Strategies

Given the diverse academic backgrounds and widely varying initial capabilities of students, the OBE core requirement that all students can achieve the intended outcomes must be honored through personalized, stratified teaching approaches.

At the beginning of the course, administer a diagnostic test covering programming proficiency (Python), mathematics background (linear algebra, probability), and prior AI exposure to group students into Basic, Intermediate, and Advanced tiers, each with explicit learning expectations. The Basic tier focuses on AI literacy and elementary tool usage; the Intermediate tier emphasizes algorithm comprehension and project practice; the Advanced tier targets innovative design and exploration of emerging techniques. For the same teaching module (e.g., Machine Learning Basics), design tiered lab tasks: the Basic group applies pre-built models and interprets outputs; the Intermediate group performs hyperparameter tuning and error analysis; the Advanced group designs customized model variants or compares multiple algorithms on real datasets. Adopt a blended online–offline mode: online LMS offers remedial micro-videos and foundational exercises for weaker students and extension materials for advanced learners; offline sessions use tiered Q&A and mixed-group collaboration. Maintain individual learning portfolios to track progress and periodically adjust grouping and scaffolding, ensuring appropriate support for every learner.

4.4. Developing a Data-Driven Formative Assessment and Continuous Improvement Mechanism

To overcome difficulties in measuring learning outcomes and the lack of process data, a multi-dimensional formative assessment system aligned with OBE principles should be institutionalized, supported by intelligent platforms for data-driven tracking.

First, specify the evaluation index system. Based on course objectives and graduation requirement indicators, define assessment dimensions: Knowledge Mastery , Practical Ability, Innovative Thinking, and Teamwork or Communication. Second, deploy or adopt a teaching process management platform to automatically collect data on online learning behaviors, experiment submissions, code commits, and project milestone completions, generating personalized learning reports to provide objective, continuous data supporting evaluators. Introduce a multi-source evaluation mechanism combining teacher assessment, student self-assessment, peer assessment, and where available enterprise mentor assessment for project practicums, ensuring alignment with industry expectations. Finally, institute a regular evaluation-feedback loop: analyze course objective attainment data each term, identify under performing teaching segments, and make evidence-based adjustments to content emphasis, instructional methods, and scaffolding strategies, thereby closing the OBE continuous improvement cycle.

5. Conclusion

Grounded in the Outcome-Based Education (OBE) concept, this paper systematically analyzes the current situation and key implementation challenges in the teaching design reform of the Fundamentals of Artificial Intelligence course, and proposes a closed-loop reform framework consisting of four interrelated dimensions: reverse goal design anchored on graduation requirement indicators, modular reconstruction of teaching content aligned with cutting-edge AI technologies, project-based and inquiry-oriented instructional activities, and diversified formative assessment with a course-objective–assessment mapping mechanism. By shifting the focus from teacher-centered knowledge delivery to student-centered capability cultivation, the OBE-oriented redesign clarifies what students should be able to do upon course completion and ensures that all curricular elements, namely syllabus, teaching modules, learning tasks, and evaluation instruments, are constructively aligned to support the achievement of those intended learning outcomes.

The identified challenges, including difficulties in translating abstract graduation requirements into measurable course objectives, the rapid obsolescence of AI teaching resources, wide disparities in students' prior knowledge backgrounds, and the lack of reliable process data for continuous improvement, are not unique to a single institution but are representative of broader difficulties encountered in implementing OBE within fast-evolving, practice-intensive disciplines. The proposed countermeasures, enhancing faculty OBE competency through systematic training and industry immersion, co-constructing dynamically updated modular resource libraries with AI enterprises, adopting differentiated scaffolding and tiered project tasks based on diagnostic testing, and deploying data-driven formative assessment platforms, provide actionable solutions to bridge the gap between OBE theory and classroom practice. Preliminary experience from similar reform attempts suggests that such an integrated approach can effectively improve students' algorithmic understanding, practical problem-solving ability, and awareness of AI ethics, while also promoting teachers' professional development and curriculum renewal.

Looking ahead, the sustainable implementation of OBE-based reform in AI-related courses calls for institutional support in terms of faculty incentive policies, intelligent teaching-management infrastructure, and long-term school-enterprise cooperation mechanisms. Future research may focus on empirically validating the proposed framework through multi-semester teaching experiments, collecting quantitative evidence on course-objective attainment and student competency growth, and exploring how emerging AI-enabled educational tools, such as automated code assessment, learning-analytics dashboards, and large-language-model-assisted tutoring, can be ethically and effectively embedded into the OBE continuous-improvement cycle. It is anticipated that persistent refinement of this outcome-oriented teaching system will not only elevate the quality of AI education but also better prepare graduates to meet the evolving demands of the artificial intelligence industry and the broader digital economy.

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