Innovation and Effectiveness Evaluation of the OBE Teaching Model in the Course of Principles of Food Engineering

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Abstract: *Against the backdrop of a shift in engineering education toward outcome-based and competency-oriented approaches, traditional didactic teaching methods can no longer meet the needs of interdisciplinary talent development. As a course with both engineering attributes and interdisciplinary characteristics, Principles of Food Engineering urgently requires a systematic reform in both teaching philosophy and structure. Guided by the concept of Outcome-Based Education (OBE), this study constructs a learning outcome–oriented instructional design pathway by focusing on four dimensions: decomposition of teaching objectives, reconstruction of content modules, task-driven activity design, and optimization of the evaluation system. The study emphasizes enhancing alignment between instructional content and competency development through a coupling mechanism of "problem–task–knowledge–competence," and achieves dynamic regulation and continuous improvement of the teaching process through a multidimensional evaluation and feedback system. This research provides a feasible model for curriculum reform in food-related disciplines and offers practical guidance for the further application of OBE in engineering education.*

Keywords: *Principles of Food Engineering; Outcome-Based Education (OBE); decomposition of teaching objectives; task-driven; teaching evaluation; curriculum optimization*

Introduction

With the continuous advancement of engineering education quality standards, teaching models are shifting from knowledge transmission to competence- and outcome-oriented approaches. The OBE philosophy centers on graduate competencies and promotes the organic integration of teaching, learning, and assessment. As a foundational course in food-related disciplines, Principles of Food Engineering plays a critical role in supporting the development of engineering competencies and the integration of interdisciplinary knowledge. However, long-standing issues such as fragmented content, singular teaching pathways, and outdated evaluation systems hinder its effectiveness. In response, this study explores a curriculum reconstruction approach under the guidance of OBE by addressing four dimensions: teaching philosophy, content design, process organization, and effectiveness evaluation. The aim is to build a systematic instructional framework oriented toward competency output and supported by learning data, thereby reinforcing the alignment between course content and competency development goals.

1. Instructional Reconstruction Logic of the Principles of Food Engineering Course under the OBE Concept

1.1 Teaching Logic and Core Features of the OBE Concept

As a key concept in contemporary higher engineering education reform, Outcome-Based Education (OBE) centers on the “measurable and verifiable” knowledge, skills, and competencies that students should possess upon graduation. It promotes systematic coordination among instructional objectives, teaching processes, and evaluation mechanisms. Under the guidance of OBE, instructional design follows a backward design approach, beginning with predefined learning outcomes and then deducing the course structure, teaching activities, and assessment systems to ensure effective support for the development of terminal competencies. Compared with the traditional teacher-centered model, the OBE model places greater emphasis on student-centeredness, competence orientation, and goal alignment. It establishes an intrinsic logical chain among knowledge acquisition, skill transfer, and holistic competency development, thereby endowing instruction with stronger intentionality and structural flexibility [1].

When applied to the field of engineering education, OBE promotes the integrated advancement of systematic knowledge, practical relevance, and data-driven assessment. It breaks away from the outdated content-heavy, course-centered teaching frameworks. Within this logic, the role of the teacher shifts toward that of a learning facilitator and assessment designer, requiring the use of task-based and project-oriented approaches to enhance students' active engagement and self-constructed learning. As a course characterized by interdisciplinary integration and engineering problem orientation, Principles of Food Engineering requires the transformation of its knowledge system into competency modules, with teaching processes closely aligned with the achievement paths of learning outcomes. The OBE concept provides a clear theoretical rationale and implementation framework for instructional innovation in this course, facilitating the shift from content-driven to outcome-oriented teaching and enhancing the course's educational effectiveness.

1.2 Knowledge Structure and Competency-Oriented Demands of the Principles of Food Engineering Course

As a fundamental core course for food-related majors, Principles of Food Engineering covers several subfields, including heat transfer, fluid mechanics, mass transfer, and unit operations. It serves as the theoretical foundation for understanding the engineering mechanisms behind food processing and mastering industrial process control methods. Beyond delivering disciplinary knowledge, the course also undertakes the dual function of professional skill development and engineering literacy cultivation. Traditional teaching often focuses on explaining theoretical laws and delivering static content, failing to adequately support the dynamic process of engineering competence formation.

Under the guidance of the OBE concept, the course must be structurally redesigned based on graduation requirements and specific competency indicators, clearly defining essential abilities students should possess by the end of the course—such as problem analysis, process design, and system modeling. From a competence-oriented perspective, the course should follow a progressive logic of "theoretical comprehension–computational application–systemic integration." Instructional content should intentionally embed real-world engineering problems, encouraging students to apply diverse knowledge to solve complex tasks in authentic or simulated contexts. For instance, when teaching fluid transport principles, it is necessary not only to introduce fundamental concepts such as Reynolds number and flow resistance, but also to incorporate industrial design tasks like pump selection and pipeline layout optimization, thereby enhancing knowledge transfer and practical relevance.

Moreover, the course should foster the coordinated development of abstract reasoning and data processing abilities by incorporating tools such as MATLAB modeling and experimental data analysis, thus enhancing students' information handling skills and constructing a composite competency framework tailored to future engineering practice. This instructional approach not only expands the functional boundaries of the course but also aligns with the trend in engineering education toward cultivating the ability to solve complex system problems [2].

1.3 Decomposition Mechanism of Teaching Objectives and Strategy for Measurable Evaluation

Within the OBE instructional framework, the effective formulation of teaching objectives serves as the logical starting point for course development. Objectives should be referenced against graduation competency indicators and systematically decomposed in accordance with the course's positioning, content structure, and skill requirements. The design must reflect not only the cognitive demands placed on students, but also the transformation paths of their learning cognition and the mechanisms for competency achievement.

To enhance operationalization and evaluability, teaching objectives should be aligned with Bloom's Taxonomy, categorizing cognitive levels into six stages: remembering, understanding, applying, analyzing, evaluating, and creating. These categories provide a foundation for organizing teaching activities and designing assessment tools. Each cognitive level must be paired with corresponding instructional activities and output criteria to ensure accurate alignment between content delivery and intended learning outcomes.

To ensure effective achievement of objectives, a scientifically sound assessment system must be established. This system should balance formative and summative evaluations and encompass student performance across dimensions such as knowledge acquisition, skill application, and cognitive development. Formative assessments may include quizzes, group discussions, and phased tasks to enable real-time monitoring, while summative assessments may involve course project reports, comprehensive experiments, and written exams to evaluate the degree of outcome attainment.

In addition, the use of quantitative analysis tools and learning analytics platforms should be leveraged to track student learning data throughout the entire process. This enables the identification of trends in learning outcomes and supports precise instructional adjustments. Discrepancies between course objectives and assessment results should inform the iterative improvement of the curriculum, thereby constructing a closed-loop quality control system characterized by "goal orientation–implementation pathway–feedback correction." This ensures continuous enhancement and dynamic updating of instructional effectiveness.

2. Systematic Design of Teaching Content and Process under the OBE Orientation

2.1 Structural Reconstruction of Teaching Modules and Sequential Organization of Knowledge Units

Driven by the OBE teaching concept, the content of the Principles of Food Engineering course must undergo structural reconstruction centered on predetermined learning outcomes. Traditional instruction often follows the logical order of knowledge points while neglecting the hierarchical nature of learning outcomes and the systematic planning of competency development pathways. In contrast, outcome-oriented instructional design requires reorganizing course content around competency development, emphasizing the functional logic, progressive difficulty, and cognitive span among knowledge units. Course modules should be guided by engineering application contexts, abandoning the linear "concept–principle–case" transmission model in favor of a four-in-one instructional unit built on "problem–task–knowledge–skill," ensuring continuity, coherence, and alignment with instructional goals throughout the learning process [3].

The sequential organization of knowledge units should reflect a progressive structure transitioning from foundational cognition to advanced application. When designing course content, a spiral teaching trajectory should be adopted in accordance with students' cognitive load and knowledge absorption patterns. Key concepts—such as food fluid mechanics, heat conduction processes, and mass transfer behaviors—should be presented in a sequence of "theory guidance–model construction–engineering application." Each instructional unit should not only deliver core disciplinary knowledge but also integrate corresponding competency modules—such as process modeling, quantitative analysis, or simulation verification—to support the stepwise achievement of learning objectives. The essence of structural reconstruction lies in dynamically aligning instructional content with course objectives, transforming teaching from a knowledge transmission process into a strategic vehicle for competency development.

2.2 Task-Driven and Problem-Oriented Instructional Activity Design

The organization of instructional activities directly affects the depth and breadth of student competency development. In OBE-based curriculum design, activities should center on "learning outcomes" and be driven by "real-world problems" to build a task-based instructional system with strong contextual relevance. Given the high engineering applicability of Principles of Food Engineering, the course lends itself well to the implementation of task-driven and problem-based learning (PBL) models. Contextualized tasks closely related to food production processes—such as heat exchanger selection, fluid transport system optimization, and drying rate modeling—can be employed to prompt students to activate knowledge, construct competencies, and reinforce understanding of engineering principles through iterative trial and model refinement.

Problem-based instruction emphasizes open-ended, complex, and integrative problems that require students to apply interdisciplinary knowledge in uncertain contexts for analysis, judgment, and decision-making. To enhance structural integrity, instructional tasks should follow a three-stage "input–process–output" design, specifying task background, solution pathways, and outcome formats to ensure a strong alignment between activity goals and course competency indicators. During implementation, instructional activities should incorporate multimodal learning methods—such as computational experiments, process simulations, group discussions, and engineering design exercises—to broaden cognitive access and stimulate higher-order thinking. In parallel, formative evaluation and real-time feedback mechanisms should be embedded to ensure that students' learning trajectories and output performance remain aligned with instructional goals.

2.3 Instructional Interaction Mechanisms and Regulation of Learning Engagement

The design of interaction mechanisms is a critical component in implementing OBE-based courses, as their effectiveness directly determines the extent to which instructional activities support learning outcomes. Given the abstract nature of knowledge and the complexity of engineering problems in Principles of Food Engineering, instructors must construct a multi-level interaction system based on dynamic feedback to enhance students' cognitive engagement and efficiency in knowledge transformation. Interaction should not be limited to one-way communication between instructor and student but should also include peer collaboration, bidirectional feedback between students and tasks, and iterative validation between students and knowledge. Within this framework, an interactive system should integrate a range of tools—such as online learning platforms, computational simulation systems, and experimental data-sharing platforms—to enable high-density, low-latency feedback throughout the instructional process.

Improving learning engagement requires real-time awareness and fine-tuned regulation of students' learning behaviors, cognitive load, and motivational states. Under the OBE framework, learning engagement is no longer a passive outcome but an active variable in instructional design. Based on a data-driven approach, instructors must dynamically adjust task difficulty, resource allocation, and instructional pacing in response to formative assessment data, learning trajectory analytics, and student feedback. On this foundation, a flexible learning environment should be established through the construction of a learning ecosystem centered on "motivation–challenge–support." Multi-dimensional incentive mechanisms—such as task points, peer evaluations, and phased presentations—can enhance students' intrinsic motivation and self-regulation, keeping learning within the optimal cognitive load range. The integration of interaction and engagement mechanisms contributes to a highly efficient, highly participatory instructional process, offering a structured guarantee for the achievement of intended learning outcomes [4].

3. Construction of an Outcome-Based Teaching Effectiveness Evaluation Mechanism

3.1 Construction and Tiered Design of a Teaching Evaluation Index System

In the outcome-based education (OBE) framework, teaching evaluation serves not only as a core tool for monitoring course quality but also as the logical endpoint for verifying the achievement of instructional objectives. The evaluation index system should be constructed based on the course's role within the overall professional training framework and should systematically address multiple dimensions, including knowledge acquisition, competency development, and literacy enhancement, all in alignment with the specific connotations of graduation competency indicators. Evaluation must move beyond merely testing knowledge recall and extend to validating comprehensive outcomes such as problem-solving skills, process modeling abilities, engineering cognition, and communication and collaboration capabilities. Based on this framework, the index system should comprise three structural layers: evaluation of overall course objectives, evaluation of teaching units, and evaluation of specific task achievement—forming a tiered and progressive assessment system.

Each evaluation layer must feature clarity, operability, and measurability. At the course level, evaluation should examine whether students meet the expected integrated competency standards upon course completion, such as the ability to analyze food engineering processes, construct mathematical models, and perform engineering optimization. At the unit level, the focus should be on the understanding and application of knowledge modules. At the task level, specific projects or experiments should be used to assess students' operational skills, teamwork, and innovation awareness. Logical correlations must be established among all evaluation dimensions to ensure the index system is both coherent and capable of capturing micro-level variations in instructional outcomes. This tiered system enhances both the systematization and precision of evaluations while also offering a structured foundation for instructional refinement and learning strategy adjustment [5].

3.2 Acquisition of Teaching Outcomes and Design of a Closed-Loop Feedback Mechanism

Teaching outcome acquisition should center on learning outputs and adopt data-driven methods to enable full-process tracking and staged sampling, thereby ensuring that deviations between actual outputs and expected results are visible, manageable, and correctable. In the Principles of Food Engineering course, teaching outcomes can be categorized into explicit and implicit types. Explicit outcomes—such as quizzes, project reports, and lab records—carry direct quantitative value, while implicit outcomes—such as class participation, learning engagement, and the process of engineering thinking development—require dynamic information collection through observations, interviews, and learning analytics. Explicit outcomes provide quantitative evidence of competency achievement; implicit outcomes reveal underlying patterns in students' learning trajectories and behavioral models. Together, they constitute a comprehensive teaching outcome acquisition system.

The teaching feedback mechanism should follow a closed-loop structure of "evaluation–feedback–adjustment–re-evaluation" and be embedded throughout the instructional process. During formative assessments, real-time feedback can be delivered through visualization platforms, prompting students to reflect and make self-directed adjustments. Following summative assessments, course iteration strategies should be devised based on attainment analysis, and feedback data should be used to refine objective setting and instructional content structure. Feedback should not be limited to the teacher's perspective but should also guide students to evaluate their own learning outcomes through learning journals, peer assessments, and reflective reports, thereby enhancing their metacognitive awareness and continuous improvement mindset. An effective closed-loop feedback system ensures that assessment tools serve not only as monitoring instruments but also play a vital role in dynamic regulation, goal calibration, and instructional optimization, providing structural support for teaching quality assurance.

3.3 Learning Outcome Analysis and Logic of Continuous Course Improvement

A learning outcome–based analysis mechanism is essential to achieving sustainable quality enhancement within the OBE teaching model. This analysis should not focus solely on students' final performance but must also account for the pathways of competency formation, the evolution of thinking structures, and the efficiency of cognitive transfer. In the Principles of Food Engineering course, longitudinal comparisons of students' phased learning outcomes and statistical analysis of horizontal variations at the same stage should be conducted to identify correlations between outcome performance and instructional input. This enables assessment of the relevance and effectiveness of instructional design. Through the construction of data visualization models and decision-support systems, the process tracking and deviation identification of key competencies—such as modeling ability, systems analysis, and design optimization—can be realized, thus providing data-based support for course refinement [6].

The logical foundation for continuous course improvement lies in transforming learning outcome data into the basis for instructional iteration, thereby facilitating the dynamic evolution of the "goal–process–outcome" triadic system. In practice, the course team should establish a periodic review mechanism and adjust course content, instructional methods, and evaluation systems based on outcome data, student feedback, and instructional observations. For instance, if most students show low achievement in the unit on "modeling the food drying process," targeted improvements may include adjusting instructional sequencing, modifying task difficulty, or adopting case-based teaching strategies. By incorporating outcome data into the course design cycle, precise alignment between instructional content and learning needs is achieved, offering a paradigm for building a responsive and goal-consistent teaching system.

Conclusion

Reform of the Principles of Food Engineering course based on the OBE philosophy must be grounded in the operationalization of instructional objectives, the competency orientation of the teaching process, and the systemic closure of the evaluation cycle. The study demonstrates that clarifying the hierarchical structure of instructional goals, reconstructing knowledge units centered on competency output, integrating task-driven and problem-oriented instructional activities, and establishing a tiered and categorized evaluation index system contribute to the systematic development of students' core competencies and the progressive improvement of teaching quality. The closed-loop design of the feedback mechanism and the refined analysis of output data provide a solid foundation for the dynamic optimization of the course.

Future research may further integrate intelligent learning analytics tools to build a personalized evaluation system driven by big data, while also exploring the broader applicability of instructional strategies across other engineering-related courses. This approach offers scalable teaching models and practical paradigms to support the extended implementation of OBE educational principles.

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