Journal of International Education and Development
2025, VOL. 9, NO. 8, 71-74
DOI: 10.47297/wspiedWSP2516-250016.20250908

Exploring Reforms in Higher Mathematics Course Teaching Under the OBE Teaching Philosophy

Jincheng Xin

Zhengzhou Normal University, College of Physics and Electronic Engineering, Zhengzhou, Henan, 450000, China

ABSTRACT
As a core foundational course in the cultivation of science and engineering talent, the quality of higher mathematics education directly impacts students' subsequent professional capabilities and innovative thinking. The current educational paradigm is undergoing a profound transformation toward outcome-based education (OBE), emphasizing a closed-loop approach to teaching design, implementation, and evaluation driven by learning outcomes. In response to the higher demands of the new industrial revolution for composite talents' analytical abilities, modeling capabilities, and application conversion skills, the traditional higher mathematics teaching model, which primarily focuses on knowledge transmission, has revealed systemic shortcomings in terms of content coherence, method adaptability, and evaluation scientificity. It is imperative to explore reform pathways that actively align with OBE principles. Therefore, this paper systematically analyzes the precise reconstruction of higher mathematics course objectives, the deep reform of content and teaching methods, and the continuous optimization of the assessment and feedback system around the core principles of OBE, to provide an operational reform framework and practical references to enhance the educational effectiveness of courses and strengthen disciplinary support capabilities.

KEYWORDS
OBE teaching philosophy; Higher mathematics; Teaching reform; Course design

1 Introduction

The accelerated evolution of contemporary technological development and industrial transformation has posed unprecedented challenges to the knowledge structure, competence, and lifelong learning abilities of engineering and technical personnel. As a foundational tool discipline supporting multiple fields such as natural sciences, engineering, technology, and information science, the modernization of teaching concepts and models for higher mathematics courses has increasingly become a key breakthrough in improving the quality of talent cultivation in higher education. With the widespread promotion of international engineering education accreditation, the outcomes-based education (OBE) philosophy has gradually become an essential paradigm for higher education teaching reform due to its core logic of focusing on learning outcomes, backward design of teaching, and continuous quality improvement [1]. In this context, the traditional teaching model of higher mathematics faces multiple practical pressures: the course content urgently needs to be more closely linked to cutting-edge disciplinary applications and engineering practice; teaching methods need to shift from one-way transmission to fostering deep thinking and problem-solving abilities; and evaluation systems must transcend single-dimensional written exams to diagnose and support the achievement of student competency goals comprehensively. Meanwhile, the updating of teachers' teaching concepts and the reconstruction of their capabilities, as well as the challenges students face in adapting to new teaching models, have become critical dimensions that require collaborative resolution in the reform process. Deepening understanding of the essence of the OBE philosophy and actively exploring innovative measures to implement it in higher mathematics courses have become urgent tasks for universities to strengthen students' mathematical foundations and adapt to the goals of cultivating innovative and applied talent, as well as an inevitable choice for achieving the intrinsic development of higher mathematics education.

2 Overview of the OBE teaching philosophy

2.1 The OBE teaching philosophy

Outcome-Based Education (OBE) is a modern educational paradigm centered on learning outcomes as the core driving force, with its core logic rooted in backward design of the teaching system. Unlike traditional "content-input" teaching, OBE first precisely defines the core competencies, knowledge structure, and comprehensive literacy that students should possess upon graduation (i. e., "learning outcomes"), using this as the logical starting point to reverse-engineer the curriculum system, teaching content, and evaluation mechanisms, thereby constructing a closed-loop structure of "goal setting → instructional design → learning practice → evaluation feedback → continuous improvement." The OBE philosophy emphasizes the measurability of competency attainment and the dynamic optimization of the teaching process: on one hand, it requires learning outcomes to be specific, quantifiable, and closely aligned with industry needs or disciplinary development; on the other hand, it involves continuously collecting multi-dimensional teaching evidence, diagnosing deviations from objectives in real time, and dynamically adjusting teaching strategies.

2.2 The impact of OBE on higher mathematics education

The introduction of the OBE concept has prompted a fundamental shift in the paradigm of higher mathematics education, profoundly reshaping the value orientation and practical approach of the curriculum. In traditional teaching, course content often followed the inherent logic of textbooks, emphasizing the integrity of theoretical systems and proficiency in problem-solving techniques. However, the OBE framework requires that mathematical abilities be redefined within professional application contexts [2]. This transformation has shifted the objectives of higher mathematics education from knowledge memorization to the cultivation of higher-order competencies such as modeling ability, logical reasoning, and the ability to translate engineering problems into practical solutions. This has necessitated the removal of redundant theoretical content from the curriculum, focusing instead on key modules that provide substantial support for core competencies. Additionally, the focus of teaching methods has shifted from teacher-centered lectures to student-driven exploration, with scenario-based task design and process-oriented guidance aimed at fostering the integration and innovation of mathematical thinking and professional practice.

3 The needs and Challenges of reforming higher mathematics courses

3.1 The urgent need for reforming higher mathematics courses

3.1.1 Updating course content and innovating teaching methods

The core issue with current higher mathematics courses is that the teaching content is severely out of sync with real-world demands, and teaching methods are outdated and monotonous. The knowledge framework of textbooks has not kept pace with technological advancements, remaining rooted mainly in the theoretical frameworks of decades past. For example, in the differential equations section, instructors still spend significant class time deriving complex analytical solutions, while modern engineering fields have long adopted numerical simulation for problem-solving; in linear algebra classes, students repeatedly practice manual calculations of determinants without understanding how these concepts underpin the core logic of data dimensionality reduction in image recognition algorithms. Although students have memorized various integration formulas, when faced with practical tasks—such as analyzing the stress distribution of wind turbine blades or designing autonomous driving path planning models—they are unable to apply these mathematical tools effectively. The issue is not only with the content but also with the teaching methods, which need to be reformed [3]. Classrooms still follow the traditional "teacher lectures, students listen" model, where knowledge points are fragmented into isolated pieces and reinforced through repetitive drills. This approach leaves most students capable of applying fixed problem types mechanically, but often helpless when faced with real-world problems requiring the establishment of mathematical models, selection of computational methods, or evaluation of result validity.

3.1.2 Emphasis on the development of students' comprehensive abilities

Advanced mathematics should not merely focus on teaching students to solve problems mechanically; it should also cultivate their scientific thinking and innovative abilities. Many students who excel in arithmetic in traditional classrooms reveal weaknesses when entering the laboratory: when analyzing motor control systems, they can list equations but fail to determine the influence weights of key parameters; when handling biological statistical data, they confuse correlation and causality, leading to incorrect conclusions. These phenomena indicate that teaching should focus on cultivating three core competencies: Mathematical modeling ability requires students to identify core variables when facing engineering problems, establish reasonable equations, and set boundary conditions; engineering judgment skills require selecting the optimal algorithm in data fitting and balancing the trade-off between computational accuracy and efficiency; and result reflection skills emphasize verifying whether solutions have physical significance, such as checking whether the compressive strength of steel exceeds standards when analyzing bridge load-bearing models [4]. To achieve these goals, teachers should incorporate specific case studies into their teaching.

3.2 Challenges faced by the current reform of higher mathematics courses

3.2.1 Teachers' traditional mindsets and inertia in teaching methods

Teachers have become the "bottleneck" of reform. Many higher mathematics teachers are accustomed to the traditional teaching model of deriving theorems on the blackboard. They exhibit psychological resistance to teaching methods that prioritize project-based practice over theoretical explanations, fearing that this shift will compromise the course's theoretical rigor. Some teachers lack understanding of fields such as machine learning modeling and fluid dynamics numerical simulation, which require advanced mathematics, making it difficult for them to design teaching cases with practical value, thereby depriving students of the opportunity to engage with cutting-edge applications. A more direct issue is insufficient technical proficiency: for example, when teachers assign tasks requiring students to solve differential equations for part thermal deformation using MATLAB programming, students encounter program errors that need debugging, but the teachers themselves are also unfamiliar with debugging techniques in the programming environment and cannot provide practical guidance. Teaching evaluation is another major challenge: after organizing students into groups to build logistics warehouse optimization models, teachers often can only grade based on whether the format of the short paper is standardized, unable to accurately assess the rationality of the modeling strategy, or the innovativeness of the algorithm design.

3.2.2 The difficulty students face in adapting to educational reform

The transformation of students' learning methods requires a gradual and systematic approach. Classes accustomed to exam-oriented education often encounter the following issues: when asked to analyze the urban heat island effect and establish a three-dimensional heat transfer model, students repeatedly ask, "Which formula should we use?" and "What are the steps to solve the problem?"When groups undertake a signal filtering project requiring the design of a Fourier transform scheme, students overlook the actual characteristics of the interference frequency band and mechanically apply the textbook example. At the end of the project, most students are only concerned with their scores and do not reflect on the defects in the model. This reflects students' cognitive challenges: they must develop the ability to independently analyze problems, accurately connect mathematical theories with technical tools, and establish self-correction mechanisms [5]. If reforms are implemented too aggressively, students may experience various discomforts: initially, they may feel lost and anxious due to the absence of question templates; during the middle phase, they may feel helpless when unable to apply matrix decomposition theory to specific noise reduction tasks; and in the later phase, they may revert to traditional answering patterns out of concern for the scoring risks associated with innovative solutions.

4 Exploring reforms in higher mathematics course instruction based on the OBE philosophy

4.1 Redesigning teaching objectives and learning outcomes

Teaching reforms based on the OBE philosophy begin with a fundamental restructuring of the objective system. Traditional higher mathematics teaching objectives have primarily focused on the mastery of knowledge as the core indicator, emphasizing proficiency in formula derivation and coverage of question types. Under the OBE framework, however, course objectives are centered on the transfer of mathematical abilities to engineering practice. By aligning with professional training standards and industry technical requirements, the necessary dimensions of mathematical literacy required for solving complex problems are identified in reverse, including nonlinear system modeling capabilities, the ability to translate abstract concepts into engineering applications, and the mathematical and logical foundations of algorithm design. Learning outcomes are thus concretized into observable behavioral indicators, such as the ability to construct differential equations describing physical phenomena independently, and the ability to analyze optimal solutions under multi-variable constraints structurally. Goal setting strictly follows the SMART principle, emphasizing the continuity and complementarity of outcomes with subsequent professional courses, thereby fundamentally transforming the current disconnect between mathematics courses and professional skill development. This goal-setting mechanism, deeply anchored in career development needs, elevates the value of the course from a single disciplinary dimension to a foundational role in cultivating engineering innovation capabilities.

4.2 Reform of course content and teaching methods

The reform of teaching content breaks away from the linear knowledge structure of traditional textbooks and establishes a knowledge grid system driven by competency requirements. The purely formalized deduction of limit theory is compressed, while the cross-integration of numerical solutions to differential equations and control system modeling is strengthened. Mechanical calculation training in multiple integrals is reduced, and case studies linking probability distributions and machine learning algorithms are increased. Course modules are reorganized around engineering problem-solving pathways, forming a three-tiered knowledge application chain of "theoretical tools—modeling pathways—practical verification." Teaching methods shift toward contextualized deep learning, with instructors creating exploratory environments through progressive engineering tasks: for example, using bridge vibration parameter identification to drive differential equation theory exploration, or leveraging logistics center site selection optimization practice to activate gradient analysis tool applications. The classroom structure breaks away from the traditional lecture-dominated model, adopting a workshop-based collaborative mechanism. Students naturally internalize mathematical thinking through the processes of scheme design, algorithm implementation, and error analysis. This transformative approach, which integrates knowledge restructuring with teaching method innovation, bridges the gap between abstract concepts and concrete innovation, effectively addressing the disconnect between theoretical instruction and real-world demands.

4.3 Innovation in teaching assessment and feedback mechanisms

The assessment system has shifted from result-based evaluation to capability-based growth diagnosis, establishing a "three-dimensional dynamic mapping" mechanism. Formative assessment includes multiple capability observation points: micro-project reports measure modeling systematicity, algorithm design reviews examine logical rigor, and open-ended experiment records track innovative application flexibility. Summative assessment breaks free from the limitations of standardized exams, setting complex problem-solving tasks in real-world engineering contexts to assess the ability to optimize mathematical methods and technical constraints synergistically. An evaluation tool, the Ability Radar Chart System, has been developed to comprehensively visualize students' progress trends across dimensions such as algorithm writing, model abstraction, and data processing, generating personalized capability enhancement pathways through gap analysis. Feedback strategies establish a closed-loop adjustment model, using weekly learning output data to drive real-time optimization of teaching content. For example, based on weaknesses in vector group theory application, specialized training in robot pose calculation is added. This mechanism of innovation, which integrates teaching, learning, assessment, and improvement into a dynamic organic system, transforms higher mathematics education into an enabling system for the growth of students' professional capabilities.

5 Conclusion

This study systematically argues for the necessity and implementation path of integrating OBE teaching concepts into higher mathematics curriculum reform. By reconstructing teaching objectives oriented toward core competencies, constructing a content and method system driven by outcomes, and innovating a dynamic, multi-dimensional assessment and feedback mechanism, higher mathematics teaching can break through the shackles of traditional textbook-centered teaching and single-dimensional evaluation, establishing a reverse design closed loop based on student development needs.

About the Author

Jincheng Xin, Master's degree, assistant professor, research interests: computational mathematics.

References

[1] Zhu Yahong, Zhao Chaojun, Qiu Wenxu. Research and Practice of a Teaching Model for "Advanced Mathematics" Based on the OBE Teaching Philosophy [J]. Science Enthusiasts, 2024, (03): 7-9.

[2] Wu Lingxia. Exploring Teaching Reform for "Advanced Mathematics" in Higher Education Institutions Under the OBE Philosophy [J]. Education and Teaching Forum, 2024, (25): 133-136.

[3] Liu Xiaojie, Wang Haimei. Research on Teaching Strategies for Higher Mathematics Courses in Vocational Colleges Under the STEM Philosophy [J]. Science Fiction Illustrated, 2024, (11): 71-73.

[4] Ji Degang. Exploring the Innovative Development of Higher Mathematics Teaching from a New Perspective: A Review of "Research on the Innovation of Teaching Philosophy and Methods in Higher Mathematics" [J]. China Oil and Fat, 2023, 48(08): 160.

[5] Ma Huizi, Miao Xuan, Wang Xiangrong, et al. Exploration of a Blended Teaching Model for Statistics Experimental Courses Under the OBE Concept [J]. Laboratory Research and Exploration, 2022, 41(09): 223-228.