WHIOCE PUBLISHING PTE. LTD.
PROVIDING FIRST-CLASS SCIENTIFIC INFORMATION FOR TOP SCHOLARS

2025 Volume 3, Issue 3
Contemporary Education Frontiers
ISSN (Online): 3029-1860 ISSN (Print): 3029-1879

Research and Practice on Establishing a Value-added Evaluation System for the Academic Achievements of Engineering Undergraduates under the OBE Concept

Ying Hai*
Guilin University of Electronic Technology, Guilin 541004, Guangxi, China

**Author to whom correspondence should be addressed.*

Abstract: Based on the Outcome-Based Education (OBE) concept and value-added evaluation theory, this study systematically examines the critical components of engineering students' academic achievement by leveraging the 12 graduate outcomes of China engineering education accreditation as a framework. Through an in-depth review of relevant literature and expert consultations, a comprehensive value-added evaluation questionnaire system with three-level indicators was constructed. This system is intended to function as a practical and reliable instrument for universities to assess the progress and attainment of students' academic achievements, thereby supporting and guiding the reform of talent cultivation practices.

Keywords: OBE; Value-added evaluation; Academic achievement

Online publication: April 26, 2025

1. New trends in higher education quality evaluation under the influence of the OBE concept

The concept of OBE, which originated in the United States in the 1970s, has gradually evolved into the dominant educational philosophy of the 21st century. The OBE philosophy emphasizes the importance of student learning outcomes, a student-centered approach, and continuous improvement. Educational activities are based on the expected learning outcomes of students, and teaching design and evaluation are carried out around the abilities and qualities that students should achieve. Influenced by the OBE philosophy, the evaluation of higher education quality has gradually shifted from a process-oriented approach to an outcome-oriented approach, focusing on the "output" of higher education, namely, students' learning effectiveness. Scholars believe that the outcome-oriented education philosophy can more directly and deeply reveal the essence of higher education quality, and the evaluation effect is more effective [1]. The Accreditation Board for Engineering and Technology (ABET) has fully adopted the OBE philosophy and integrated it into the engineering education accreditation standards [2]. Countries such as the United States, Japan, the United Kingdom, Australia, and Canada have applied the outcome-oriented philosophy and issued corresponding assessment guidelines, accreditation standards, and degree requirements, all highlighting the requirements for measuring and evaluating students' learning outcomes [3].

Academic achievement, broadly, refers to learning outcomes and performance, encompassing knowledge, skills, behaviors, attitudes, and thinking habits learners acquire after completing the learning process. It can be evaluated through cognition, affect, and practical application [4]. Under the OBE framework, the academic achievements of college students in higher education institutions can be categorized into three levels:

(1) At the institutional level, this refers to the accomplishments graduates should achieve in societal and professional contexts within five years of graduation. These align with the institution's overarching talent development goals, focusing on a macro perspective;

(2) The major level, which focuses on the knowledge, skills, and competencies that students are expected to acquire upon graduation. These are usually defined as the program-specific graduation requirements, which are measurable and operational;

(3) The course level, referring to the learning outcomes students attain after completing a specific course, is often represented by the achievement of course objectives. Since institution-level goals are long-term and broad, while course-level objectives are fragmented and detailed, evaluating undergraduate academic achievement focuses on the major level, specifically assessing graduation requirements. These requirements define the key benchmarks for knowledge, skills, and competencies students should meet upon graduation, reflecting both student development quality and institutional education effectiveness [5].

The *Washington Accord* has established a framework comprising 12 graduate outcomes that undergraduate engineering students are expected to achieve by the time they graduate. Each accredited program can develop more specific graduation requirements based on this framework, provided that these requirements fully encompass the content of the 12 core outcomes.

Under the OBE , the focus of evaluation transitions from the teaching process to students' learning outcomes. This shift drives higher education institutions to prioritize talent cultivation quality and ensure that students achieve expected academic outcomes. The "outcome-oriented" evaluation approach also generates a series of profound impacts: First, it promotes personalized evaluation. As the OBE concept focuses on individual development, evaluations assess each graduate's academic achievements at graduation, providing insight into students' learning states and enabling tailored teaching support. This encourages students to prioritize self-development and achievement during learning. Second, it places greater emphasis on competency evaluation. Under the OBE framework, the evaluation system focuses more on students' high-order competencies, such as solving complex problems, critical thinking, and teamwork skills. Third, it promotes self-assessment. Among the ten major challenges identified by the U.S. National Learning Outcomes Assessment Center in output evaluation is "enhancing students' self-assessment to optimize the learning process" [6]. Students must be able to actively monitor and assess their learning progress and outcomes, as self-evaluation is crucial for lifelong learning and career development.

2. The migration and application of value-added evaluation in the field of college students' academic evaluation

OBE has facilitated the transformation of educational evaluation concepts and established an evaluation model centered on learning outcomes. The assessment of students' learning outcomes now serves as the core component of higher education quality evaluation. However, it is important to note that the "outcome orientation" in OBE does not equate to "result orientation," which focuses solely on the final result while neglecting the process. Instead, OBE emphasizes the logical coherence of the entire process leading to the achievement of outcomes. It is essential not only to define the outcomes students are expected to achieve but also to understand how to guide them toward achieving these outcomes [7]. The process of achieving outcomes and its assurance are integral to the OBE framework and should be incorporated into the evaluation criteria.

There is currently no unified standard for evaluating graduation requirement achievement. Disciplines typically use both quantitative and qualitative methods. Quantitative methods analyze course grades to calculate indicator point attainment through a graduation requirement matrix. Qualitative methods involve surveys and interviews, where recent graduates subjectively assess their achievement of each indicator.

Current methods, whether quantitative or qualitative, are summative assessments that evaluate academic achievement at graduation. While they provide feedback on learning outcomes, they lack ongoing process monitoring and hinder real-time improvement. These methods often focus on institutional performance rather than individual student development. Monitoring learning outcome changes during student development helps track progress and improve teaching, aligning with the purpose of value-added evaluation.

Value-Added evaluation assesses educational effectiveness by measuring the added value educational activities provide to students' expected learning outcomes. It primarily tracks changes in college students from enrollment to graduation or assesses academic gains after completing a study segment compared to its onset. This method integrates evaluations of learning initiation, process, and outcomes [8]. Applying value-added evaluation to academic achievement evaluation enhances the effectiveness of such evaluations.

2.1. Value-added evaluation helps students clarify their academic achievement goals

OBE emphasizes outcome orientation, and students' academic achievements are gradually accumulated throughout their four years of study. Implementing value-added evaluation facilitates the prediction of learning outcome achievement. By measuring changes in students' academic performance between two distinct time points and providing feedback on the evaluation results, this approach can not only help students gain a comprehensive understanding of the academic achievements they are expected to attain, enabling them to become "purposeful learners," but also offer insights into the extent to which preset goals have been achieved for both institutions and individual students [9].

2.2. Value-added evaluation is conducive to students' self-improvement and self-actualization

"Student-centeredness" and a focus on students' progress are the shared principles of both OBE and value-added evaluation. Value-added evaluation involves self-comparison for individual students rather than inter-student comparison, emphasizing personal growth and self-improvement over ranking and elimination. If academic early warning is a negative list for academic achievements, value-added evaluation is a positive one, like creating a Gantt chart for learning. It highlights changes in student outcomes through quantitative analysis and progress visualization, serving as a strong motivational tool [10].

2.3. Value-added evaluation is conducive to the effectiveness and timeliness of continuous improvement

OBE emphasizes continuous improvement. Consequently, identifying what to improve and how to improve it becomes a critical concern. Value-added evaluation examines changes at both institutional and individual levels while focusing on the impact of various factors on academic achievement development [11]. Its findings can serve as a foundation for schools to implement continuous improvement initiatives. For example, if value-added evaluation reveals that students' innovation and practical skills are insufficiently developed, schools can adopt targeted strategies, such as reforming the experimental teaching framework, introducing integrated and innovative experimental courses, and expanding extracurricular innovation and practice opportunities.

Against the backdrop of OBE, constructing a scientific value-added evaluation system is of great significance for guiding teaching improvement, enhancing educational quality, and promoting students' comprehensive development.

3. Framework design for the value-added evaluation system of engineering students' academic achievement

3.1. Defining evaluation objectives

The core objective of the evaluation is to guide universities in optimizing their educational training systems, not to facilitate horizontal comparisons across colleges or majors. Therefore, the research focuses on a detailed examination of the attainment of various indicators during the training process, specifically, students' progress in meeting graduation requirements, to provide a comprehensive understanding of the effectiveness of talent cultivation.

3.2. Clarifying assessment content

Based on the outcome-oriented principle of OBE, the academic achievements of engineering students are primarily embodied in the graduation requirements. Consequently, this study designs the index system using the 12 graduate outcomes outlined in the Engineering Education Accreditation Criteria (2022 Edition) as a framework. This approach not only adequately reflects the professional expectations for students but also informs the reform of university talent development through measurable outcomes.

3.3. Determining assessment methods

Student academic achievement evaluation can be categorized into four types based on the content and form of the evaluation [12]. The first type involves direct assessment of professional knowledge and skills through course examination results. The second type involves indirect assessment of professional knowledge and skills attainment using indicators such as credit accumulation and graduation rates. For example, Shanghai Ranking Consultancy employs the quality score of new student intake as the independent variable and the postgraduate admission rate of the same cohort as the dependent variable to construct a linear regression model. This model calculates the expected value of the postgraduate admission rate and compares it with the actual value to derive the residual. The standardized residual is then used to compute the value-added standard score for undergraduate students [13]. The third type employs standardized tests to evaluate general competencies, such as the U.S. Collegiate Assessment of Academic Proficiency (CAAP). The fourth type utilizes self-report scales or questionnaires on non-cognitive abilities, where students provide feedback on their learning experiences, outcomes and satisfaction to assess academic achievement. Examples include the U.S. National Survey of Student Engagement (NSSE) and Tsinghua University's NSSE-China survey. This method is currently widely adopted by many universities [14], as scholars generally consider it significant for improving university teaching and administration [15]. After analyzing the pros and cons of the four approaches, the study concludes that, from the university administrators' perspective, the self-report questionnaire on non-cognitive abilities best aligns with the research objectives.

3.4. Design the index system framework

A reasonable evaluation of academic achievement requires clear evaluation dimensions and a specific indicator system. This provides the logical foundation and critical reference for effective and efficient evaluations [16]. The 12 graduate outcomes also include 38 observation points. Without appropriate dimension classification, analyzing and organizing questionnaire results in later stages becomes difficult, requiring further refinement of the dimensional structure.

Scholars both domestically and internationally have proposed diverse approaches to categorizing the dimensions of college students' academic achievements. For instance, Professor Shi Jinghuan from Tsinghua University classifies the growth of college students into two primary dimensions: Academic development involves knowledge acquisition, skill development, scientific thinking, and methodological training for college students. Social development focuses on their ability to manage relationships, establish self-identity, and cultivate social responsibility [17]. In the United States, the Educational Testing Service (ETS) evaluates student learning outcomes across dimensions including general education skills, career preparation skills, specific leadership skills, soft skills, and student engagement. Meanwhile, the American College Testing (ACT), categorizes these dimensions into core academic skills, educational and career navigation skills, cross-disciplinary skills, and behavioral skills [18]. Based on the above findings, the first-level indicators can be divided into cognitive and non-cognitive abilities, or academic and social development.

Cognitive abilities primarily pertain to students' academic accomplishments, encompassing high-order thinking skills, research competencies, and professional qualities. Non-cognitive abilities focus on students' social development, involving civic literacy and lifelong developmental capabilities. The correspondence between these abilities and the 12 graduate outcomes of engineering accreditation is presented in **Table 1**.

Table 1. Framework of the evaluation questionnaire index system for academic achievement enhancement of engineering college students

Dimensions	Categories	12 graduate outcomes corresponding to
Cognitive abilities (Academic development)	Higher-order thinking ability	Engineering knowledge, Problem analysis, Design/development of solutions
	Research capabilities	Investigation, Modern tool usage
	Professionalism	Engineer and society, Environment and sustainability, Professional ethics, Project management
Non-cognitive ability (social development)	Civic literacy	Individual and team work, Communication
	Autonomous development	Lifelong learning

3.5. The demonstration and optimization of the indicator system

To validate and refine the evaluation indicators, the research team solicited feedback from management departments and faculty involved in engineering education accreditation. Grounded in the evaluation objectives and principles, expert opinions were systematically integrated and analyzed. Based on the discussion outcomes, the third level of the index system was enhanced. The original 12 graduate outcomes were restructured into 18 items, with scenario-based and representative questions designed to improve the questionnaire's operability and relevance. This process established a comprehensive three-level index system structure. Below is a detailed elaboration of the third-level indicator design:

3.5.1. Higher-order thinking ability

The graduate outcomes for "Engineering knowledge," "Problem analysis," and "Design/development of solutions" emphasize the integration of "mathematics, natural science, and engineering fundamentals" as well as the resolution of complex engineering problems. These also incorporate elements of innovative thinking. Consequently, this dimension includes four items: "Knowledge Integration," "Problem Analysis," "Design and Innovative Thinking," and "Problem Solving." For instance, the question for "Knowledge Integration" reads: "When completing assignments or addressing practical problems, I can synthesize knowledge across different courses for analysis."

3.5.2. Research capabilities

This dimension aligns with "Investigation" and "Modern tool usage." Specifically, "Investigation" highlights the application of scientific principles, the utilization of modern tools, and a comprehensive evaluation of existing information. Correspondingly, the assessment items include "Quantitative Reasoning," "Technical Application," and "Critical Thinking." For example, the question for "Quantitative Reasoning" is: "I can independently analyze numerical data (e.g., charts, experimental results) and utilize the derived information to solve problems." Meanwhile, "Critical Thinking" refers to students' capacity to critically evaluate existing knowledge and discern truth from falsehood.

3.5.3. Professionalism

This dimension corresponds to "Engineering and society," "Environment and sustainability," "Professional Ethics," and "Project management" in the graduation requirements. It primarily encompasses societal, environmental, ethical, and managerial knowledge relevant to the engineering field—qualities essential for engineering students. Four items were thus designed: "Social Responsibility," "Sustainable Development Concept and Action," "Professional Ethics," and "Project Management."

3.5.4. Civic literacy

This dimension aligns with "Individual and team work" and "Communication." These emphasize interpersonal dynamics, teamwork, writing and communication skills, and cross-cultural competencies. These are not only critical for engineering students but also foundational qualities for all citizens. Five items were developed: "Teamwork," "Communication," "Reading Ability," "Expression Ability," and "Cross-cultural Competence."

3.5.5. Autonomous development

This dimension corresponds to "Lifelong learning" in the graduation requirements. With its two key aspects, "learning" and "adaptation," two items were identified: "Lifelong Learning Concept" and "Environmental Adaptability." The questionnaire focuses on the "Lifelong Learning Concept" due to college students' current learning-centric stage, emphasizing the examination of their conceptual understanding. The corresponding question is: "I recognize that knowledge evolves rapidly and believe that continuous learning throughout life is essential, which I strive to implement in practice."

3.6. The next step is to refine the plan

In December 2024, CEEAA Releases Engineering Education Accreditation Criteria (2024 Edition). To ensure that the evaluation system remains aligned with the evolving landscape of teaching practices and effectively supports the enhancement of talent cultivation quality and efficiency, timely adjustments and optimizations to the evaluation system are necessary.

Funding

General Project of Guangxi Education Science Planning Education Evaluation Reform Special Topic, "Research on Value-added Evaluation of Undergraduate Academic Development Based on the Concept of Outcome-oriented Education" (Project No.: 2022ZJY459)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhao T, Yang Y, 2017, College Student Learning Outcomes Assessment: Comparison and Analysis on 5 Thinking Ability Tests. China Higher Education Research, 2017(3): 49–55.

[2] Li Z, Zhu H, Liu Z, et al., 2018, Guiding the Reform of Higher Engineering Education with Result-oriented Educational Ideas. Research in Higher Education of Engineering, 2018(2): 29–34 + 70.

[3] Zhou X, Yu J, Huang C, 2021, Outcome-based Education: Theoretical Origin, Development and Application. Higher Education Development and Evaluation, 37(3): 83–90 + 113.

[4] Zhang J, Sun K, 2013, Academic Achievement Evaluation in Higher Education Institutions: Review of Research and Practices. Modern Education Management, 2013(10): 62–65.
[5] Zhu L, Hu D, Wang K, et al., 2024, On the Evaluation of the Achievement of Graduate Outcomes Based on Outcome-based Engineering Education Principles (Part 1). Research in Higher Education of Engineering, 2024(3): 42–57.
[6] Li Z, Li Q, 2023, Student Learning Outcomes Assessment: Practices and Enlightenments of American HEIs. Research in Higher Education of Engineering, 2023(2): 6–13.
[7] Li Z, Zhao W, 2021, Recent Progress of Engineering Education Accreditation in China. Research in Higher Education of Engineering, 2021(5): 39–43.
[8] Yang Z, Ding X, 2021, Enhance the Quality of Talent Cultivation Through Value-Added Evaluation. Guangming Online, visited on May 25, 2021, https://kepu.gmw.cn/2021-05/25/content_34872189.htm.
[9] Liu H, 2012, The Rise of Value-added Assessment Mode and Application in American Higher Education. Journal of Higher Education, 33(5): 96–101.
[10] Zhang H, Liu D, 2023, Model Construction and Application of Improvement-based Value-Added Assessment of Student Learning. Journal of China Examinations, 2023(6): 1–10.
[11] Hu J, Xu X, 2022, Value-Added Assessment in Higher Education: Origins, Debates and Reflections. Fudan Education Forum, 20(6): 5–11 + 18.
[12] Shi J, et al, 2020, Research on the Learning and Development of Chinese College Students in the Popularization Stage. Zhejiang Education Publishing House, Hangzhou, 255.
[13] Shanghai Ranking Consultancy, 2024, Shanghai Ranking's Global Ranking of Academic Subjects Methodology 2024, visited on November 6, 2024, http://youkud.com/tool/referance/index.html#google_vignette.
[14] Ding X, 2019, An International Comparison of Collegiate Learning Outcome Assessments. Journal of Higher Education Management, 13(6): 45–54.
[15] Li X, Zhou Z, Liang X, 2013, A Literature Review of Research on Value-Added Assessment and Quality Assurance in Higher Education: From the Aspects of Theories and Methods. Tsinghua Journal of Education, 34(4): 40–45.
[16] Huang X, 2019, Theoretical and Practical Exploration of the Evaluation of the Intrinsic Development Level of Higher Education. Jiangxi Social Sciences, 39(9): 239–246.
[17] Shi J, et al, 2020, Research on the Learning and Development of Chinese College Students in the Popularization Stage. Zhejiang Education Publishing House, Hangzhou, 258.
[18] Zeng X, 2020, Research on Non-governmental Institutions Assessment of American College Students Learning Outcomes, thesis, Sichuan International Studies University.

Publisher's note

Whioce Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.