

Cultivating OBE Competencies in Emerging Engineering Disciplines to Serve New Quality Productive Forces

Yanling Zhao, Xiaoming Wu, Bin Ma, Guangqi Liu*

School of Computer Science and Technology, Qilu University of Technology (Shandong Academy of Sciences),
Jinan, Shandong 250306, China

*Correspondence Author, 10378741@qq.com

Abstract: *The connotation and evolution of new quality productive forces represent a core driver for high-quality economic development, placing new demands on competency cultivation in emerging engineering disciplines. This paper first interprets the essence of developing new quality productive forces and analyzes the corresponding higher requirements for talent cultivation in emerging engineering fields. Subsequently, it examines the advantages of the Outcome-Based Education (OBE) philosophy and elaborates on how integrating emerging engineering discipline construction with OBE competency cultivation serves as a crucial pathway for enhancing the level of new quality productive forces. Finally, using the development of an emerging engineering discipline (Computer Science) at a provincial university as a case study, it outlines methods and strategies for cultivating professional talents' OBE competencies from the perspective of developing new quality productive forces, aiming to provide robust talent support for industrial upgrading and socio-economic development.*

Keywords: New Quality Productive Forces, Computer Science Major, Outcome-Based Education (OBE), Competency Cultivation.

1. Introduction

Since 2023, the innovative concept of “new quality productive forces” has been proposed, emphasizing the need to “smooth the virtuous cycle among education, science and technology, and talent in accordance with the requirements for developing new quality productive forces.” Among the various elements of the national innovation system, talent is the most fundamental and dynamic element, serving as vital support and guarantee for cultivating and developing new quality productive forces. Cultivating high-quality laborers and innovative talents adapted to future technological development and industrial needs is the primary factor in developing new quality productive forces [1-3].

The construction of emerging engineering disciplines is a proactive initiative by higher engineering education to address the challenges of the new round of technological revolution and industrial transformation, driven by the strong demand for reform in higher engineering education from the new economy characterized by new technologies, industries, business forms, and models. Its construction goals are highly aligned with the demands of developing new quality productive forces. Concurrently, the Outcome-Based Education (OBE) philosophy emphasizes market demand orientation, focuses on student competency development, and stresses the close integration of the educational process with industrial needs. The organic integration of emerging engineering discipline construction and the OBE educational philosophy is a significant pathway for promoting the development of new quality productive forces [4].

Based on the core requirements for developing new quality productive forces, and integrating the construction of emerging engineering disciplines and the OBE educational philosophy, this paper analyzes the current status and related issues of OBE competency cultivation in emerging engineering disciplines. It explores measures and methods for

cultivating high-quality talents in these fields, aiming to provide specific ideas and references for talent cultivation in emerging engineering disciplines, thereby better serving the development of new quality productive forces.

2. High Requirements of New Quality Productive Forces for Emerging Engineering Talent Cultivation

Emerging engineering disciplines are set against the backdrop of the new economy and new industries, representing a strong demand from the new economy—characterized by new technologies, industries, business forms, and models—for reform in higher engineering education. The development of new quality productive forces imposes higher requirements on engineering and technical talents, reflected in the following aspects:

1) Greater Emphasis on Integration of Cutting-Edge Technologies and Interdisciplinary Knowledge. New quality productive forces focus on technological integration, breaking through the elemental boundaries of traditional productive forces, organically combining cutting-edge fields such as digital technology, artificial intelligence, biotechnology, and new energy, thereby forming an interdisciplinary and cross-domain innovation ecosystem [5].

2) Greater Emphasis on Innovation Capability and Complex Problem-Solving Skills. The development of new quality productive forces centers on technological innovation, encompassing innovations in new technologies, products, models, and business forms. It requires capabilities for analyzing and solving complex engineering problems, engineering design and implementation, engineering testing and optimization, etc., to implement technological optimization and innovative application, effectively driving industrial development [6].

3) Greater Emphasis on Adapting to the Needs of Emerging and Future Industries. Factors such as continuous breakthroughs in frontier technologies and market demands have given rise to numerous emerging and future industries. The development of new quality productive forces requires engineering and technical talents to possess the ability to adapt to the development of these industries. Higher education should closely align with industrial needs, through industry-education integration, university-enterprise cooperation, etc. [7], allowing students to train in real work scenarios and cultivate practical application abilities.

4) Greater Emphasis on Lifelong Learning and Sustainable Development Capability. The rapid development of new quality productive forces requires engineering and technical talents to possess lifelong learning, human-machine collaboration capabilities, and sustainable development capabilities to adapt to rapidly changing technological environments. Curriculum systems and teaching methods should focus on cultivating talents' self-directed learning ability and innovative application skills, enabling them to continuously enhance their own quality and meet the demands of future industries [8].

3. Current Status and Issues of OBE Cultivation in Emerging Engineering Disciplines

3.1 OBE Educational Philosophy and Emerging Engineering Discipline Construction

The OBE educational philosophy is a curriculum system development concept that is goal-oriented towards outcomes, student-centered, and employs reverse thinking. It first emerged in basic education reforms in the United States and Australia and was later adopted and promoted by many countries and regions worldwide.

Emerging engineering disciplines require accelerating the construction and development of new engineering majors, exploring more diverse and personalized talent cultivation models, and cultivating engineering and technological talents with innovation, entrepreneurship, and cross-border integration capabilities. They primarily aim to address major national, industrial, and technological needs, supporting and leading the development of the new economy.

3.2 Current Status of OBE Cultivation in Emerging Engineering Disciplines

The implementation of the OBE educational philosophy is relatively mature abroad and has become a mainstream model in the field of engineering education. Many universities worldwide optimize their curriculum systems through the OBE concept, emphasize student competency development, focus on practical teaching, and adopt quantitative assessment methods. For example, the American engineering education accreditation system (ABET) and the engineering education models under the Washington Accord framework both take OBE as their core, establishing clear training objectives and graduation requirements to build a complete closed loop from curriculum design to teaching evaluation. Furthermore, foreign universities also emphasize faculty professional

development, enhancing teachers' engineering practice capabilities and teaching abilities through various means.

Many domestic universities are also continuously exploring talent cultivation models based on the OBE philosophy. For instance, Shantou University introduced the OBE philosophy for educational reform as early as 2005 and achieved certain results. In 2016, the Ministry of Education timely proposed the concept of "emerging engineering disciplines" and actively promoted activities such as the "Fudan Consensus," "Tianjin Action," and "Beijing Guide," further highlighting the urgency of the "emerging engineering disciplines" educational reform. Additionally, some local engineering universities are promoting the implementation of the OBE philosophy by optimizing curriculum systems, strengthening practical teaching, and constructing diverse evaluation systems [9].

3.3 Problems in OBE Cultivation for Emerging Engineering Disciplines

Despite some progress in past reform practices, the implementation of OBE cultivation in emerging engineering disciplines still faces numerous problems and challenges, as detailed below:

1) Disconnection between Training Objectives and Industrial Needs. While the OBE philosophy emphasizes orientation towards future industry needs, universities often still center on disciplines when formulating training objectives and curriculum settings, failing to fully consider the actual needs of industrial development. This can easily lead to difficulties for graduates in achieving a "seamless connection" with job positions, resulting in a significant gap between their knowledge structure, skill levels, and market demands.

2) Insufficient Support for Competency Output in the Curriculum System. Influenced by traditional education, the current university curriculum system often suffers from an unreasonable distribution of theoretical and practical class hours and insufficient coherence between courses. Course content is disconnected from the needs of new quality productive forces, lacking comprehensive, design-oriented, and innovative projects. The rigid practical teaching model further impacts the cultivation of students' practical abilities.

3) Weak Engineering Practice Capability of Faculty. Implementing the OBE philosophy requires a teaching faculty with stronger teaching abilities and engineering practice backgrounds. The current situation in universities, which often "emphasizes research over teaching," limits teachers' enthusiasm for participating in teaching reforms. Simultaneously, teachers generally lack engineering practice experience, while the commonly introduced industry mentors often lack educational teaching experience.

4) Deficiency in Educational Resource Supply. Implementing the OBE philosophy requires rich, cutting-edge teaching resources that match and adapt to the development of new quality productive forces. However, constrained by factors such as funding and management methods, universities are often unable to update teaching resources promptly. Insufficient construction of practical bases and a lack of

diverse collaborative supply lead to issues in practical teaching, such as inadequate equipment, outdated resources, and disconnection between practical projects and real engineering, affecting the cultivation of students' engineering practice capabilities.

4. Strategies and Practices for OBE Competency Cultivation in Emerging Engineering Disciplines

This paper takes the Computer Science major at Qilu University of Technology as a representative emerging engineering discipline to explore the OBE competency cultivation system under the demands of new quality productive forces.

4.1 Reverse-Design Modular Curriculum System

Closely connect with and investigate industry needs. Starting from the requirements of industry, enterprises, and socio-economic development for talent training specifications, reversely design the curriculum system, optimize course articulation and content arrangement, ensure the logic and coherence between courses, and form an organic curriculum system.

Taking the Computer Science major as an example, establish competency training objectives combining "Knowledge + Ability + Literacy" and "Theory + Practice + Output," and reversely design modular course clusters such as "Professional Basic Courses, Professional Core Courses, Professional Direction Courses, and Professional Extension Courses." Establish a dynamic adjustment mechanism for the curriculum system, promptly introducing frontier technologies and knowledge related to new quality productive forces (e.g., AI, big data, blockchain) to maintain the advancement and timeliness of course content. Integrate theoretical teaching with practical teaching organically, enabling students to deepen their understanding of knowledge through practical operation in a timely manner. Strengthen industry-academia-research collaborative education, allowing students to practice in real engineering scenarios, understand industry dynamics and enterprise needs, and improve their professional literacy and employment competitiveness.

4.2 Hierarchically Progressive Design of Practical Ability Output System

Classify and formulate practical teaching standards according to the characteristics of the major and talent training requirements, clarifying the proportion of practical teaching in the curriculum system. Set up diverse practical courses, such as experimental courses, course projects, comprehensive practice, internships, and graduation projects. Design a hierarchically progressive practical teaching system with levels like "Basic Practice, Professional Practice, Innovative Practice, Comprehensive Practice," and set up corresponding courses.

Taking the Computer Science major as an example, set up basic practice in programming courses (e.g., C, Java, Python) and courses like "Computer Organization" and "Database Principles" in the first and second years, enabling students to

master basic concepts, skills, and tools of the major. Set professional practice in courses like "Data Structures," "Computer Networks," and "Software Engineering" in the second and third years, involving tasks such as implementing various data structures and algorithms, network programming experiments, and participating in small-scale software project development. Offer innovative practice courses like "Computer Science and Technology Innovation Practice" in the third year, organizing students for innovation project selection, design, and implementation to stimulate innovative thinking and capability. Set comprehensive practice courses like "Production Internship," "Graduation Internship," and "Graduation Project" in the senior year, cultivating students' ability to comprehensively apply acquired knowledge and skills to solve complex engineering problems.

4.3 Strengthening Innovative Practice Links Throughout the Entire Process

Reduce verification experiments and increase design-oriented, comprehensive, and research-oriented experimental projects to enhance students' innovation and practical abilities. Update practical teaching content in line with economic, social, and technological progress, incorporating applications of new technologies, equipment, and methods. Adopt teaching methods based on problems, projects, and cases, implement "theory-practice integrated teaching models" to enhance student learning motivation.

Taking the Computer Science major as an example, add a "Computer Science and Technology Innovation Practice" course, designing comprehensive and innovative projects to progressively enhance students' innovative awareness and engineering practice ability. Assign supervisors with scientific research and innovation capabilities to students, invite entrepreneurs and innovation experts to serve as external mentors, providing guidance throughout the student practice process, enabling students to work on "real topics and real tasks" in innovation projects. Encourage key laboratories and research institutions to open to undergraduates, supporting student participation in research projects. Establish university-level, provincial-level, and national-level innovation and entrepreneurship training programs to fund students' innovative research. Encourage students to participate in national innovation and entrepreneurship competitions such as the "Challenge Cup" and "Internet+" to promote learning through competition and cultivate students' scientific research ability and innovation spirit.

4.4 Building a Higher Education Industry - Academia - Research Community

Universities should not only cooperate with leading industry enterprises but also actively collaborate with research institutions, industry associations, etc. Enterprises provide actual project requirements and application scenarios, research institutions output frontier technological research results, and associations act as bridges, coordinating resources from all parties and promoting deep integration of industry, academia, research, and application.

For example, the Computer Science major, considering the university's positioning, discipline characteristics, and talent

training objectives, can jointly build industry-education integration communities with software R&D enterprises, AI research institutes, and computer industry associations, co-constructing off-campus practical teaching bases. Focusing on key technological bottlenecks in industries, establish integrated platforms for “industry – academia – research – transfer – innovation - application” through building industry colleges, technology innovation alliances, university science parks, etc., to achieve deep integration of talent cultivation, scientific research, technological innovation, and enterprise services. Explore cross-regional, cross-industrial chain collaborative cooperation, creating a “multi-cross coordination” model. Organize interdisciplinary teaching teams to carry out interdisciplinary teaching projects, cultivating students’ teamwork and interdisciplinary communication skills.

Acknowledgement

This work was supported by the Shandong Province Key Undergraduate Teaching Reform Research Project (Grant Nos. Z2023291, Z2024170), the Key Teaching-Research Project of Qilu University of Technology (Shandong Academy of Sciences) (Grant No. 2024zd01), the Tender (Major) Teaching Reform Research Project of Qilu University of Technology (Shandong Academy of Sciences) (Grant No. z202303-2). Additionally, the teaching team was recognized as an Outstanding Teaching Team of Qilu University of Technology (Shandong Academy of Sciences). This project was honored with the Top Prize of the Qilu University of Technology Outstanding Teaching Achievement Award.

5. Summary

Guided by the philosophy of OBE competency output for emerging engineering talents, it is essential to vigorously promote the integration of science and education with teaching, and deepen industry-academia collaboration, constructing a deeply integrated talent cultivation cooperation mechanism. Emphasis should be placed on the organic combination of professional course instruction and practical knowledge learning, and the coordinated use of school teaching spaces and enterprise practical spaces, to cultivate the research capabilities and practical abilities necessary for high-quality talents to enter the market.

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