International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 22, No. 2, 2026

Reconstruction Paths for the Teaching System of Food Engineering Majors from the Perspective of Emerging Engineering Education

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Abstract: In response to new technological and industrial shifts and national food security needs, traditional food engineering education faces challenges in interdisciplinary integration, innovation, and digital literacy. Guided by Emerging Engineering Education principles, this study proposes a teaching reform framework centered on "smart, sustainable, and integrated" development. Key measures include redesigning interdisciplinary curricula, deepening industry-academia-research collaboration, adopting digital pedagogy, and integrating sustainability and civic education. The aim is to cultivate versatile talent with practical skills, innovative capacity, and social responsibility, thereby supporting food industry advancement and national security goals.

Keywords: Emerging Engineering Education, Food Engineering, Teaching System Reform, Industry-Education Integration.

1. Introduction

Food security is a matter of fundamental national importance. With the deepening implementation of China's food security strategy and the accelerated transition of the industry towards smart and green development, a structural disconnect has become increasingly apparent between higher education in food engineering and the cutting-edge demands of the industry [1-2]. Traditional curriculum systems inadequately integrate emerging technologies, practical teaching components remain weak, and the innovation of talent cultivation models lags behind. Therefore, amidst the wave of Emerging Engineering Education (3E) initiatives, systematically advancing the reform of the food engineering teaching system has become an imperative task of our time, one that is crucial to national strategy, the future of the industry, and educational development [3-4]. This study aims to explore and construct a new model for cultivating food engineering talents that aligns with the needs of the new economic landscape and the national food security strategy.

2. Background

2.1. Status of Current Research

Domestic initiatives have unfolded across multiple dimensions, focusing on interdisciplinary integration, industry-education collaboration, and practical innovation. Regarding interdisciplinary convergence, some universities have systematically promoted the deep integration of food engineering with fields such as information technology and artificial intelligence by establishing characteristic discipline clusters and pioneering interdisciplinary degree programs [5]. In terms of industry-education collaboration and joint talent development, effective practices have emerged, including building "dual-qualified" teaching teams (with both academic and industry expertise), implementing mechanisms for two-way personnel flow between universities and enterprises, and incorporating real-world corporate projects into the curriculum [6]. Concerning practical teaching and digital transformation, practice-oriented courses spanning the entire industrial chain and national-level teaching reform plans provide systematic guidance for Emerging Engineering Education.

Internationally, leading institutions, exemplified by Wageningen University & Research in the Netherlands, have long integrated information technology and life sciences deeply into agriculture and food engineering education. They widely employ project-based and blended learning models, emphasizing the cultivation of students' sustainability mindset and global perspective [7]. These domestic and international experiences offer valuable insights for this study.

2.2. Core Concepts and Theoretical Foundations

The theoretical basis of this study is derived from three primary aspects:

Emerging Engineering Education (3E) Philosophy: Emphasizes adaptability and future-readiness, focusing on interdisciplinary convergence, industry-education collaboration, and cultivating students' innovative mindset and practical skills [8].

Industry-Education Integration Theory: Stresses the alignment of the educational chain and talent pipeline with the industrial chain and innovation chain, aiming to resolve the structural mismatch between talent cultivation and industrial demands [9].

Outcome-Based Education (OBE) Framework: Advocates for a backward design of the curriculum centered on student learning outcomes, ensuring that educational objectives directly correspond to national strategic and industrial needs [10].

3. Pathways for Reforming the Teaching System of Food Engineering under the Emerging Engineering Education Framework

3.1. Constructing a New Interdisciplinary "Grain Engineering+" Integrated Curriculum System

The core of the reform lies in breaking down traditional disciplinary boundaries and constructing a "concentric circle" curriculum system centered on the discipline of grain engineering, radiating outward to integrate with other fields.

At the heart of this system are traditional core courses upgraded through intelligent and green transformations. For example, Grain Processing Technology is enhanced to become Intelligent Grain Processing Technology, incorporating cutting-edge content such as digital twins and intelligent control [11]. The intermediate layer consists of key interdisciplinary "Grain Engineering+" course modules, including: " Grain Engineering + Information Technology": offering courses such as Grain Big Data Analysis and Agricultural Artificial Intelligence; " Grain Engineering + Biotechnology": featuring courses like Applications of Biotechnology in Grain and Oil; " Grain Engineering + Intelligent Manufacturing": including courses such as Design of Intelligent Grain Machinery and Equipment [12-13]. The outermost layer comprises the latest industry frontier case studies and practical projects, such as large-scale grain storage models, intelligent grain sampling robots, air-supported membrane silo technology, and grain loss reduction engineering. These serve as dynamic teaching content and exploratory topics, continuously infusing and revitalizing the entire curriculum system.

Through knowledge flow and feedback from the core to the outer layers, this system aims to systematically cultivate a new generation of interdisciplinary "grain talent" equipped with cross-disciplinary knowledge structures and the ability to solve complex industry problems.

3.2. Innovating a Practice-oriented Education Mechanism through Deep Industry-education Integration

Practical teaching is the soul of engineering education, necessitating the establishment of a long-term, deeply intertwined, and mutually beneficial industry-education integration mechanism. This mechanism is jointly driven by the supply side (universities) and the demand side (industry), achieving efficient alignment of resources and needs through the establishment of an "Industry-Education Integration Collaborative Education Platform"[14].

The platform’s operation is reflected in four dimensions of "collaboration": (1) Co-constructing Entities: such as jointly establishing industry colleges, university-enterprise joint laboratories, and internship and training bases. (2) Co-delivering Teaching: fully implementing the "Dual Mentor System" and project-based learning (PBL), appointing enterprise technical experts as industry professors to co-guide students. (3) Co-researching Projects: transforming real-world enterprise technical challenges (e.g., the development of AI-based monitoring algorithms for grain pests) into graduation projects or comprehensive course design topics. (4) Co-sharing Outcomes: jointly supporting students' innovation and entrepreneurship competitions and technology incubation.

This mechanism constructs a closed-loop system that flows from talent supply to industry demand, and then feeds back into talent supply through collaborative education. Its ultimate output is high-quality, interdisciplinary engineering talent that closely aligns with the transformation and upgrading needs of the grain industry.

3.3. Advancing the Digital Transformation and Intelligent Enhancement of Teaching Models

Utilizing modern information technology to comprehensively enhance teaching efficiency and the learning experience is paramount. The focus lies on developing virtual simulation teaching resources such as the "Grain Storage Intelligent Management VR Simulation System" and the "Full-Process Grain Processing Digital Twin Experiment Platform." These resources enable students to engage in safe, low-cost, high-level practical training within virtual environments. Simultaneously, the promotion of blended teaching models based on MOOCs (Massive Open Online Courses) and SPOCs (Small Private Online Courses) is essential. This involves implementing flipped classrooms that combine "online self-directed learning" with "in-depth offline seminars." Furthermore, exploring the use of AI technology to construct knowledge graphs based on student learning behavior data will facilitate intelligent recommendation and customization of personalized learning pathways.

3.4. Deepening the Integration of Curriculum Ideological and Political Education with Sustainable Development Concepts

Integrating value cultivation, knowledge imparting, and capability building into a cohesive whole. Within professional courses, ideological and political elements such as "food security and national strategy," "the inheritance of the spirit of grain and agriculture," and "ethics of green processing" are organically embedded. By recounting national achievements and the exemplary deeds of industry role models, students are guided to establish a sense of mission and responsibility for "safeguarding the nation’s grain. "Simultaneously, sustainable development concepts such as the "broad food concept," "storing grain through technology," and the "circular economy" are integrated throughout the entire teaching process [15]. Through practical projects focused on themes like grain loss reduction and the high-value utilization of by-products, students' ecological awareness and sense of social responsibility are fostered.

4. Conclusion

Driven by the dual imperatives of emerging engineering education and the national food security strategy, reforming the teaching system for the grain engineering major has become an urgent necessity. The systematic reform framework proposed in this study-grounded in interdisciplinary integration, guided by industry-education collaboration, empowered by digital intelligence, and rooted in fostering virtue and cultivating talent-aims to fundamentally address the bottlenecks of traditional talent cultivation. Through reconstructing the curriculum system, innovating practical mechanisms, transforming teaching models, and elevating educational philosophy, this framework can effectively cultivate outstanding grain engineering professionals who are future-oriented and mission-driven. In doing so, it will lay the most solid talent foundation for firmly holding the "Chinese rice bowl."

Acknowledgments

This work was supported by Jiangsu Provincial University

Philosophy and Social Science Fund Project (2025SJYB0203) and Nanjing University of Finance and Economics School level Education Reform Project (XJWC3202457).

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