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Research on Curriculum System Construction Featuring "Engineering-Education Integration and Multi-party Collaboration" in Application-Oriented Universities

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Abstract

With the growing demand for high-quality application-oriented talents driven by industrial upgrading, the disconnect between traditional university curriculum systems and professional competency requirements has become increasingly prominent. Centered on the concept of "Engineering-Education Integration and Multi-party Collaboration", this paper explores reform pathways for curriculum systems in application-oriented universities. Through analyzing models such as industry-education integration and university-enterprise collaboration, we propose a three-tiered progressive curriculum framework encompassing "foundational competencies-professional competencies-comprehensive competencies", validated through case studies to provide references for cultivating application-oriented talents.

Keywords

Application-Oriented Universities, Engineering-Education Integration, Multi-Party Collaboration, Curriculum System, Industry-Education Integration.

1. Introduction

1.1. Research Background

Under the dual drivers of Emerging Engineering Education initiatives and industrial transformation/upgrading, application-oriented universities face new challenges in talent cultivation. Conventional curriculum systems exhibit critical limitations, including: disconnection between theoretical instruction and practical training, underdeveloped university-enterprise collaborative mechanisms, and oversimplified assessment protocols. These deficiencies result in structural mismatches between talent cultivation outcomes and evolving industrial demands[1-2]. The Outcome-Based Education (OBE) philosophy provides innovative solutions through constructing an "Engineering-Education Integration and Multi-Stakeholder Collaboration" curriculum framework. OBE's core principle of "backward design" - starting from desired learning outcomes to reconfigure curriculum systems - aligns precisely with application-oriented talent development objectives. Specifically: Engineering-Education Integration facilitates deep convergence of technical competencies and theoretical knowledge via project-based teaching and authentic scenario practices[3]. Multi-Stakeholder Collaboration establishes an industry-education ecosystem through systematic integration of academic institutions, enterprises, and industrial resources[4]. This study investigates practical pathways for implementing OBE-guided curriculum innovation, proposing actionable strategies to cultivate high-quality application-oriented talents responsive to advanced manufacturing requirements.

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1.2. Research Significance

The construction of a curriculum system featuring "Engineering-Education Integration and Multi-Stakeholder Collaboration" in application-oriented universities carries significant theoretical innovation and practical guidance value. On the theoretical level, it systematically establishes a theoretical framework for the curriculum system that integrates engineering-education convergence and cross-sector collaboration, thereby deepening research on application-oriented talent cultivation models. On the practical level, through innovative industry-education integration mechanisms, it effectively addresses critical issues in traditional curricula—such as disconnections from industrial demands and insufficient practical training—while markedly enhancing students' engineering competencies and career competitiveness[5]. The research outcomes not only provide replicable paradigms for curriculum reform in peer institutions, but also establish strategic talent pipelines supporting regional industrial upgrading, while holding significant practical implications for advancing synergistic development between higher education and industries.

2. Organization of the Text

2.1. Connotation Development of the "Engineering-Education Integration and Multi-Stakeholder Collaboration" Curriculum System

The "Engineering-Education Integration and Multi-Stakeholder Collaboration" curriculum system centers on cultivating application-oriented talents in materials-related disciplines. Through deep integration of educational and industrial chains, it constructs a dynamic curricular ecosystem characterized by "industry-education embeddedness and competency progression".

Engineering-Education Integration focuses on systematic convergence of theory and practice.

Curriculum Content: Guided by industrial frontiers (e.g., intelligent manufacturing, industrial internet), industry standards are deconstructed into modular knowledge units, restructuring discipline-specific course clusters into a three-tiered curricular chain: Fundamental Theory → Technical Application → Engineering Innovation. Teaching Methodology: Employing Project-Based Learning (PBL), progressive instructional modules are designed around real-world engineering challenges (e.g., material forming, advanced material R&D), structured as: Classroom Experiments → Virtual Simulations → Enterprise Internships. In faculty development, the institution implements a "dual-teacher mobility mechanism," where academic faculty lead theoretical instruction while industry engineers co-deliver courses and co-supervise practical training through university-enterprise partnerships, achieving bidirectional knowledge transfer between industrial expertise and academic pedagogy.

Multi-stakeholder collaboration constructs an interconnected education network. University-enterprise synergy establishes industrial colleges to convert corporate R&D projects into teaching cases; university-government synergy integrates policy resources to build shared training bases and industry-education integration platforms; international collaboration adopts the CDIO (Conceive-Design-Implement-Operate) framework and aligns with globally accredited curricula to cultivate global engineering competencies. Industry associations drive curriculum updates through technology trend reports, forming a closed-loop mechanism of "demand feedback → content iteration → evaluation optimization".

This system achieves the organic integration of knowledge delivery, skill cultivation, and career development through deep engineering-education integration and multi-resource collaboration, providing systematic support for materials-related application-oriented talents to adapt to industrial upgrading.

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2.2. Curriculum System Construction Pathway

The development of the "Engineering-Education Integration and Multi-Stakeholder Collaboration" curriculum system for application-oriented materials programs centers on professional competency cultivation. Through a tripartite linkage of "goal orientation → structural design → implementation safeguards", it establishes a practical pathway characterized by demand-driven development, competency-progressive enhancement, and dynamic optimization.

2.2.1. Goal Orientation Guided by Professional Competencies

Application-oriented materials programs in universities aim to serve the upgrading of the new materials industry by constructing a curriculum system of "Engineering-Education Integration and Multi-Stakeholder Collaboration", with a focus on cultivating application-oriented talents possessing three core professional competencies.

In terms of engineering practice competencies, emphasis is placed on equipping students with job-critical skills such as 3D printing equipment debugging and composite material forming process optimization. For interdisciplinary integration competencies, efforts are directed toward fostering hybrid technical application capabilities in areas like "Artificial Intelligence + Material Manufacturing" and "Industrial Internet + Quality Inspection". Regarding career sustainability competencies, lifelong learning modules (e.g., industry technology frontier lectures, career planning workshops) are implemented to develop students' self-directed learning abilities and professional resilience in adapting to industrial transformations. This goal framework, grounded in the Outcome-Based Education (OBE) philosophy and industry demands, prioritizes practical training, emphasizes interdisciplinary convergence, and underscores sustainable development, thereby supplying high-quality technical talents for the new materials sector.

2.2.2. Three-Tier Progressive Curriculum Design

Application-oriented materials programs establish a "Foundation-Integration-Innovation" three-tier progressive curriculum system, forming a spiral competency development pathway. Oriented toward professional competency progression, this system achieves stepwise enhancement of students' professional literacy through organic articulation of knowledge, skills, and innovation.

The Foundation Tier emphasizes consolidating disciplinary fundamentals through general education courses (e.g., Engineering Ethics, Technical Writing) and core professional courses (e.g., Mathematical Modeling, Engineering Drafting). Practical modules such as numerical simulation of material properties and smart manufacturing blueprint design cultivate students' essential professional literacy and technical competencies.

The Integration Tier adopts project-based teaching by integrating authentic industry cases. For example, real-world projects like lithium battery cathode material process optimization inform practice-oriented courses such as Materials Engineering Comprehensive Training, which implements theory-experiment-practice integrated pedagogy. Capstone projects employ an industry-mentored "real-world problem-solving" approach (e.g., designing industrial robot-assisted material processing systems), strengthening engineering practice capabilities.

The Innovation Tier prioritizes interdisciplinary integration and innovation-entrepreneurship development. Initiatives include organizing "Internet + Material Manufacturing" competitions, launching new material R&D projects, and leveraging maker spaces for technology commercialization. These efforts foster creative thinking, entrepreneurial skills, and sustainable career momentum through iterative prototyping and market-driven innovation.

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2.3. Implementation Safeguards

The materials discipline's "Engineering-Education Integration and Multi-Stakeholder Collaboration" curriculum system has established a dynamic and multi-dimensional safeguarding mechanism. By implementing a curriculum dynamic adjustment mechanism, annual joint surveys with industry associations and leading enterprises are conducted to assess industrial technological demands. Course modules are updated (e.g., adding hydrogen energy material preparation and Industrial Internet technology applications) to align with emerging trends in new materials and smart manufacturing. Concurrently, ISO quality management systems and Industry 4.0 technical specifications are translated into pedagogical standards, ensuring synchronized evolution between curriculum content and industrial technological advancements.

For quality evaluation, a "process-outcome-innovation" diversified assessment system is constructed. Industry mentors conduct dual-dimensional evaluations (technical operations + professional literacy) for practical training projects. Authoritative certifications such as the Certified Materials Engineer credential are adopted as competency benchmarks, while innovation competition achievements (e.g., "Internet+" and "Challenge Cup") are incorporated into innovation assessments. This forms a three-dimensional evaluation network spanning the entire teaching chain, guaranteeing precision alignment between talent cultivation quality and industry requirements.

2.4. Implementation Outcomes

2.4.1. Case Background

The materials program (author-affiliated) serves aerospace and regional new materials industries, aiming to cultivate high-quality application-oriented engineering talents. In recent years, the school has adopted Outcome-Based Education (OBE) to redesign its curriculum system, enhancing students' engineering practice and innovation capacities to meet modern manufacturing demands.

Through systematic analysis of materials engineers' competency requirements, the school established a "Industry Needs → Competency Goals → Curriculum System → Teaching Implementation → Continuous Improvement" reform pathway, focusing on core competencies in material design, process optimization, and failure analysis.

2.4.2. Specific Measures

Curriculum Restructuring: Developed a competency-curriculum mapping matrix, integrating courses like Engineering Materials & Thermal Processing and adding frontier courses such as Computer Applications in Materials.

Three-Tier Practice System: Established a progressive framework—basic experiments (material characterization) → comprehensive training (forming processes) → innovation projects (aerospace lightweight design)—with over 60% enterprise-based projects.

University-Enterprise Collaboration: Co-founded 5 industry colleges with partners, implemented International Welding Engineer (IWE) certification standards, and ensured 95% of capstone projects address real engineering challenges under dual mentorship.

Dynamic Evaluation: Formed an industry-expert committee to annually assess competency metrics and update curricula based on technological advancements.

2.4.3. Effectiveness Analysis

In recent years, materials-related programs have achieved remarkable improvements in talent cultivation quality. Student achievements in national competitions, including the National Metallography Skills Competition, have increased by 80%. Graduate employment alignment with industry needs has surged from 75% to 90%, while enterprise evaluations indicate a 50%

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reduction in job adaptation periods. Deep industry-academia integration has been realized through the establishment of 3 university-enterprise joint laboratories, accompanied by a 30% annual growth in industry-sponsored R&D funding and 5 technologies commercialized for industrial upgrades.

3. Conclusion

This study develops an "Engineering-Education Integration and Multi-Stakeholder Collaboration" curriculum system based on the Outcome-Based Education (OBE) philosophy. By deeply integrating theory with practice and strategically aligning university-enterprise resources, it effectively addresses critical challenges in application-oriented talent cultivation, including outdated curriculum content, insufficient practical training, and inadequate industry-academia collaboration. Taking materials-related disciplines as an example, the three-stage progressive curriculum framework ("Foundational → Professional → Comprehensive Competencies")—supported by a competency-curriculum mapping matrix, a three-tiered practice system, and dynamic evaluation mechanisms—achieves systematic cultivation of engineering competencies and professional literacy. Implementation outcomes demonstrate that the system significantly enhances students' innovative capacities and job adaptability, elevates graduate employment alignment with industry needs, and fosters effective industry-academia technology reciprocity and research collaboration, thereby providing robust talent support for regional industrial upgrading. This achievement offers a replicable reform model for peer institutions and explores actionable pathways for higher education to advance regional economic development through talent-driven innovation ecosystems.

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References

[1] Y J Wang, R Sun, S M Liu, et al. Construction and Practice of Welding Technology and Engineering Course Clusters from the Perspective of Specialty-Innovation Integration[J]. Modern Education and Practice, 2024, 3(6): 225-227.

[2] Y J Wang, R Sun, S M Liu, et al. Teaching Reform and Practice of Welding Technology and Engineering Specialty under the Background of Specialty-Innovation Integration[J]. Modern Education and Practice, 2024, 6(6): 224-226.

[3] Y Jiang, B Wang, S Q Kou, et al. Approaches to Deepen Industry-Education Integration in Application-Oriented Universities[J]. Journal of Higher Education, 2024, 10(36): 102-105.

[4] D Ma, G Y Liang, Q Y Yang, The new social contract for education attributes of industry education integration and its construction paths[J]. Vocational and Technical Education. 2025, 1(46): 42-47.

[5] Y J Wang, L Zhao Y Peng, et al. Microstructure and Toughness of Laser Welding Seam of Medium Manganese Automobile Steell[J]. Chinese Journal of Lasers, 2022, 49(8): 227-237.