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EXPLORING THE CONSTRUCTION PATH OF A COLLABORATIVE EDUCATION MODEL FOR COURSE CLUSTERS IN INTERDISCIPLINARY PROGRAMS INTEGRATING MANAGEMENT AND ENGINEERING

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Abstract: Against the backdrop of promoting the development of emerging engineering and liberal arts disciplines and implementing the fundamental task of moral education, the collaborative education model for interdisciplinary curriculum groups in management and engineering faces several challenges, including insufficient integration, limited faculty capacity, and inadequate alignment of teaching methods and evaluation mechanisms. In response, a systematic construction path is proposed: reconstructing the curriculum objectives system to establish a trinity framework of "value guidance–knowledge transmission–ability cultivation", with clearly defined ideological and political education integration points; innovating teaching models through case-driven and scenario-based approaches to achieve organic integration and implicit permeation of educational values within professional curricula; strengthening faculty development by implementing a dual-instructor system to enhance teacher competencies and foster collaboration between professional course instructors and student mentors; and improving the evaluation mechanism by establishing a combined formative and value-added assessment system to scientifically measure educational effectiveness. This pathway aims to provide practical guidance for the effective implementation of collaborative education in interdisciplinary programs integrating management and engineering, with the goal of cultivating high-quality, versatile talents equipped with professional skills, patriotic dedication, social responsibility, and a sound understanding of engineering ethics. It also offers valuable insights for other interdisciplinary fields.
Keywords: Interdisciplinary of management and engineering; Emerging engineering education; Emerging liberal arts education; Collaborative education

1 INTRODUCTION

In the context of a new round of scientific and technological revolution and industrial transformation, national strategic demands have placed higher requirements on the knowledge structure, competencies, and value orientation of high-level interdisciplinary talents[1]. Interdisciplinary programs that integrate management and engineering—such as industrial engineering, logistics engineering, and engineering management—are characterized by a strong emphasis on cross-disciplinary integration. Their curricula combine theories and technologies from management, economics, data science, and engineering, aiming to address complex problems in system planning, design, operation, and optimization[2]. Graduates from these programs play a crucial role in driving industrial upgrading and national development.

Curriculum-based ideological and civic education (commonly referred to as "curriculum civics") serves as a key measure for implementing the fundamental task of fostering virtue through education. It seeks to integrate value shaping, knowledge transmission, and ability cultivation throughout the entire teaching and learning process [3-4]. For interdisciplinary programs that bridge management and engineering, talent cultivation must go beyond equipping students with solid management thinking and strong engineering practice capabilities. It must also instill in them firm ideals and convictions, a profound sense of patriotism, high moral standards, a strong sense of social responsibility, and a sound understanding of engineering ethics. Only in this way can graduates integrate technological innovation and managerial optimization with national development, social progress, and public well-being in their future careers, making decisions and contributions that align with the core values of socialism.

However, the construction of the collaborative educational model for management-engineering interdisciplinary curriculum groups faces many unique challenges:

Complex and Diverse Knowledge Systems: Integrating multidisciplinary knowledge requires the educational model to accommodate different disciplinary backgrounds and logics, making it prone to phenomena like "forced grafting" or "superficial generalization."

Strong Concealment of Value Orientation: The values embedded in technical courses (such as engineering management and systems optimization), like "efficiency-first" and "cost-priority," may potentially conflict with educational

requirements (such as "people-oriented," "sustainable development," and "social responsibility"), requiring precise identification and effective guidance.

Discrepancy in Teacher Cognition and Practice: Some specialized teachers lack sufficient depth of understanding and ability to integrate educational elements. They may perceive the concept as an additional burden or merely pay lip service, lacking the awareness and effective methods to integrate it into specialized teaching.

Need to Enhance Student Identity: Students may focus more on learning technical skills, have insufficient understanding of the importance of the educational model, or consider it unconnected to their specialized studies, leading to insufficient motivation for learning.

Currently, research systematically exploring effective pathways for constructing curriculum group-based educational models specifically in the field of management-engineering interdisciplinary programs remains insufficient. Existing studies either focus on macro-level explanations or concentrate on practices within a single discipline. There is a lack of in-depth analysis and practical validation regarding the difficulties, entry points, and integration models for constructing curriculum group-based educational models under the complex characteristics of management-engineering interdisciplinary programs.

Based on this, this paper focuses on management-engineering interdisciplinary programs, delving deeply into the effective pathways for constructing the curriculum group-based educational model.The research aims to:

- Systematically analyze the construction logic of the curriculum group-based educational model for management-engineering interdisciplinary programs;
- Explore methods and carriers for identifying and integrating educational models that align with the characteristics of management-engineering interdisciplinary disciplines;
- Construct an organically integrated curriculum group-based educational model combining "value guidance-knowledge imparting-ability cultivation";
- Propose concrete strategies to enhance teachers' educational capabilities and stimulate students' value identity;
- Provide reference-worthy theoretical frameworks and practical solutions for constructing curriculum group-based educational models in similar interdisciplinary programs.

This study holds significant theoretical value and practical significance for deepening the educational essence of management-engineering interdisciplinary programs, improving the quality of talent cultivation, and serving major national strategic needs.

2 THE VALUE LOGIC OF CONSTRUCTING THE EDUCATIONAL MODEL FOR MANAGEMENT-ENGINEERING INTERDISCIPLINARY CURRICULUM GROUPS

The construction of the educational model for specialized curriculum groups must be grounded in the essence of the discipline and the laws of education. The value logic of the educational model for management-engineering interdisciplinary curriculum groups manifests as a three-dimensional unity of governance logic, disciplinary logic, and pedagogical logic. This logical system not only addresses the "necessity of why it must be done" but also reveals the underlying motivations of "how it can be done."

2.1 Strategic Alignment: Dual Motivation from National Development Goals and Talent Cultivation Needs

The construction of interdisciplinary curriculum models in engineering-management programs must primarily align with broader national development goals. The "dual carbon" targets, for example, have driven the optimization of production systems and the restructuring of course standards [6-7]. In logistics path optimization experiments, carbon emission cost functions have been introduced, turning sustainable development strategies into quantifiable engineering decision-making parameters. At the policy level, the New Engineering Education Development Guide clearly states that "major undertakings rely on talent," providing strategic guidance for the integration of management and engineering education. This dual motivation—national-level demand and educational mission—requires that course objectives be anchored in talent development, aiming to cultivate well-rounded professionals equipped with both engineering and management capabilities.

2.2 Disciplinary Logic: Integration of Cross-Domain Knowledge with Embedded Educational Values

The core of disciplinary logic lies in uncovering the intrinsic alignment between domain knowledge in engineering-management fields and value-based educational elements. From a methodological perspective, the "whole-part" analytical framework in systems engineering aligns naturally with holistic thinking models, while the PDCA cycle in quality management echoes the experiential learning theory of "practice–reflection–re-practice." At the knowledge module level, lean production courses can incorporate exemplary figures such as renowned welding expert Gao Fenglin, elevating standardized procedures into expressions of craftsmanship. Similarly, blockchain-enabled supply chain systems—such as the traceability mechanisms used in smart logistics—illustrate integrity through technically verifiable processes. Case studies on major project risk management also serve as practical materials to cultivate responsibility and teamwork. This knowledge-value integration demonstrates how the dual nature of "engineering + management" can foster deeper ethical awareness and responsible conduct, becoming a unique strength of value-oriented education in interdisciplinary programs [8-9].

2.3 Pedagogical Innovation: Leveraging Interdisciplinary Features to Transform Educational Methods

The pedagogical logic focuses on how the interdisciplinary nature of engineering and management can enhance educational innovation [10-11]. First, through immersive, real-world scenarios such as smart factory simulations and emergency dispatch exercises, courses move beyond abstract discussion and foster authentic value reflection. Second, value-based content is naturally embedded in course design and corporate internships, supporting the internalization of principles through hands-on experience. Third, students' decision-making processes are digitally tracked and visualized, enabling a data-driven understanding of their value preferences. This type of practice-based teaching transforms subject-matter strengths into educational advantages, constructing values through "learning by doing" and significantly improving educational impact [12-13].

3 IMPLEMENTATION PATHWAYS FOR VALUE-BASED EDUCATION IN ENGINEERING-MANAGEMENT PROGRAMS

In response to the core challenges outlined above, this study proposes a four-dimensional implementation framework consisting of: learning objectives – instructional design – faculty development – evaluation mechanisms.

3.1 Reconstruction of the Curriculum System of the Trinity Integration Framework

The ideological and political construction of the cross-disciplinary courses of foremen is the primary way to solve the fundamental problems of blurring goals and integrating blunt integration [14-16]. Based on the concept of results-oriented education (OBE), this research constructs a three-dimensional coupled curriculum goal framework of "value-leading-knowledge transfer-ability training", and realizes the deep penetration of the education model from the "suspended surface" to the "professional core" through systematic anchoring, structured transformation and closed-loop implementation. In terms of value dimension, it closely integrates national needs such as the strategy of a manufacturing powerhouse and the dual-carbon target, and transforms macro-policies into actionable curriculum instructions: for example, "Green Logistics System Design" relies on national carbon emission trading policy data and requires students to calculate the ecological cost of transportation path optimization, so that the strategic requirements can be transformed into Algorithm parameters that can be executed in the classroom. In the knowledge dimension, we will focus on promoting the genetic reorganization of professional knowledge logic and educational elements: the "Production System Optimization" curriculum reconstructs the knowledge map, adds a "life cycle assessment" module, and incorporates non-technical elements such as environmental protection regulations into the constraints of production functions; "Project Financing" introduces the "Belt and Road" infrastructure investment. Financing cases make geopolitical risk analysis an essential knowledge unit for project feasibility studies. In the dimension of competence, it breaks through the rational limitations of traditional engineering education tools, and adds composite literacy indicators such as social benefit assessment, ethical decision-making, and strategic thinking: the curriculum design of "Disaster Emergency Management" is mandatory to incorporate the "Vulnerable group rescue priority" decision tree model, transforming humanitarian values into programmable scheduling algorithms. In order to ensure the landing of the three-dimensional goal, the "Professional competence-ideological and political literacy mapping matrix" tool was developed. Taking the "Logistics System Planning" course as an example, its "Distribution center site selection" module clearly corresponds to the literacy index of "urban-rural balanced development Index", and the "Transportation path optimization" module links to "Carbon reduction per unit cargo loss". The evaluation value finally forms a closed-loop mechanism of "goal setting-process monitoring-effectiveness feedback".

3.2 The Construction of a Silent Integrated and Innovative Teaching Model

In this study, it is urgent to transcend the superficial dilemma of "embedding education modules" [17-18], and this study proposes a three-axis driven teaching model of "situation-case-data", relying on the interdisciplinary characteristics to achieve the implicit penetration and organic integration of values. Based on the theory of contextual cognition and the principle of embodied learning, the construction of an immersive decision-making field integrating virtual and real has become a key breakthrough point: in the course of "Intelligent Manufacturing System", the AR sand table of the Hong Kong-Zhuhai-Macao Bridge project is developed, and students need to adjust the construction plan under typhoon conditions, and the system provides real-time feedback on the ethical cost curve of "construction period compression-worker safety risk", so that the value of "life first" can be transformed into perceptible decision-making pressure. Based on Python, the decision-making behavior collection plug-in was developed to record the frequency of students clicking the "Employee Rest Area Optimization" button in the digital sand table of "Factory Layout Planning", so as to form a baseline map of educational literacy. This infiltration path of "context-triggered cognitive conflict-case-driven value speculation-data quantitative behavior selection" internalizes abstract concepts such as craftsmanship and low-carbon ethics into an instinctive frame of reference for engineering decision-making.

3.3 Construction of The Teaching Staff For Collaborative Education In Professional Education

The "deficit in value transformation ability" faced by teachers of cross-disciplinary professional courses in management and engineering is a key bottleneck restricting the effectiveness of ideological and civic-minded education. This study

pioneers a "three-stage dual-teacher system" collaborative education model, creating cross-disciplinary and cross-field teaching collaboration through ability reshaping, mechanism innovation, and ecological reconstruction. The basic level focuses on the cognitive upgrade of the education model and conducts subject-specific training: for industrial engineering teachers, a module titled "Decoding the Craftsmanship Spirit in Lean Production" is developed, dissecting the millimeter-level precision philosophy of Ning Yunzhan, a master of high-speed rail bogie grinding. A "Blockchain and Integrity Gene" workbench was customized for information management teachers. Through the traceability system of Cainiao Logistics, the governance rules of the Alibaba platform were deduced in reverse, and the technical logic was transformed into a moral education script. The collaborative layer breaks down disciplinary barriers and establishes a deep coupling mechanism between professional course teachers and educational mentors: In the "Engineering Ethics" course, educational mentors and professional teachers jointly teach, focusing on the handling of the water seepage accident in the Jiaozhou Bay Undersea Tunnel, and cross-teach "Materialist Dialectics of Risk Decision-making" and "Failure Probability Model of Waterstop Materials". The ecological layer expands the educational field and builds a sustainable development closed loop of "capability certification - resource feedback" : Develop a radar chart assessment tool for teachers' educational qualities and incorporate "original achievements" into the innovation indicators for professional title evaluation. This three-stage evolutionary path of "cognitive empowerment - mechanism innovation - ecological feedback" enables teachers to transform from passive executors of the education model to active designers of value creation.

3.4 The Evaluation Mechanism for Scientifically Quantifying the Effectiveness of Education has Been Improved

The effectiveness evaluation of ideological and civic-minded education in cross-disciplinary courses of management and engineering has long been plagued by problems such as "subjectivity" and "unpredictability". This study constructs a three-dimensional anchoring evaluation system of "process - value-added - society", and realizes the visualization, quantification and verifiability of educational achievements through technological empowerment. Process-based evaluation focuses on capturing the trajectory of value decision-making behavior: The course "Logistics Center Planning" uses Python to develop a decision backtracking plugin, which automatically calculates the click retention rate of social variables such as "priority of delivery to old residential areas" and "setting up channels for the disabled" during the scheme modification stage, forming a micro-behavior baseline database. Develop a radar chart tool for educational effectiveness to compare the edge data of students' abilities in dimensions such as "environmental sustainability" before and after the "Project Management" course, and achieve dynamic tracking of individual growth. Socialized evaluation runs through the closed loop of educational practice: This system innovates the "Data Fusion Cockpit" platform, mapping heterogeneous data such as behavior logs, scale increments, and enterprise ratings into the conversion rate curve of "value cognition - emotion - behavior", providing a universal technical paradigm to break the ambiguity of ideological and civic-minded education.

4 CONCLUSION

The construction of the curriculum cluster education model for the interdisciplinary major of management and engineering is an era proposition that responds to the national strategic demands and the transformation of educational paradigms. This study establishes a three-dimensional value logic model of civic affairs - discipline - teaching", reveals the transmission mechanism from national strategies to curriculum goals, clarifies the genetic isomorphism between systems engineering thinking and educational methodology, and demonstrates the enabling effect of cross-practice on the internalization of values. At the practical level, a four-dimensional path breakthrough is formed: the target system is reconstructed through the trinity framework of "value - knowledge - ability"; Innovating the integration model of "context - case - technology", the decision-making sand table of the Hong Kong-Zhuhai-Macao Bridge materializes ethical choices as engineering parameters. The Huoshenshan Virtual Teaching and Research Room has established a "dual-teacher co-evolution mechanism" to achieve a deep integration of technical logic and value education. Develop the three-dimensional evaluation paradigm of "process - value-added - society", and realize the visualization of educational achievements by relying on technical tools such as the literacy radar chart. This study establishes three principles of paradigm shift in interdisciplinary education: from mechanical embedding to gene integration, from preaching and indoctrination to context construction, and from subjective evaluation to technical empirical evidence. Its core value lies in proving that professional logic itself is the carrier of value transmission, providing a scalable methodological system for cultivating new engineering talents with both a sense of patriotism and innovation ability.

COMPETING INTERESTS

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