Curriculum and Teaching Methodology (2026)
Clausius Scientific Press, Canada
DOI: 10.23977/curtm.2026.090407
ISSN 2616-2261 Vol. 9 Num. 4

Interdisciplinary and Industry–Education Integration for ICV Talent Training Reform Driven by Large Models and Intelligent Agents

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Keywords: Large Model Foundation; Intelligent Agent; Interdisciplinary Integration; Industry–Education Integration; Intelligent Connected Vehicle

Abstract: The rapid advancement of intelligent connected vehicle (ICV) industries and emerging engineering education reform has generated an urgent demand for interdisciplinary and practice-oriented engineering talents. Nevertheless, conventional single-discipline training modes in universities are constrained by rigid disciplinary boundaries, fragmented curriculum systems, and shallow university–enterprise cooperation, resulting in a prominent talent supply–demand mismatch that severely restricts industrial high-quality development. To address these critical dilemmas, this study proposes an innovative "one subject, two pillars" talent training framework empowered by large models and intelligent agents. This novel intelligent education paradigm effectively breaks traditional educational limitations by clarifying the system's internal coupling mechanism and closed-loop operational logic. Corresponding reform strategies covering organizational collaboration, curriculum reconstruction, practical teaching optimization, faculty development and dynamic evaluation are systematically formulated. This research provides a rigorous theoretical basis and replicable practical paradigm for advancing ICV compound talent cultivation, and offers valuable insights for the digital and intelligent transformation of emerging engineering education.

1. Introduction

Intelligent connected vehicle (ICV) technologies have advanced rapidly in technological iteration and industrial deployment, constituting a core strategic component of modern intelligent transportation systems and national transportation development strategies [1]. As a critical enabler for large-scale autonomous driving commercialization, vehicle–infrastructure cooperation integrates theories and technologies across vehicle engineering, traffic engineering, control science, computer science, communication engineering, artificial intelligence and data security. Its intertwined technological chains and dynamically updated application scenarios impose stringent requirements on engineering professionals with systematic thinking, interdisciplinary competence and practical capabilities to resolve complex engineering challenges [2].

Emerging engineering education reform highlights interdisciplinary convergence and deep industry–education collaboration to cultivate high-caliber engineers adaptable to industrial technological upgrading [3, 4]. The emergence of large models and autonomous intelligent agents has driven fundamental transformations in higher engineering education [5-7]. These emerging artificial intelligence tools support adaptive knowledge matching, integrated resource scheduling and dynamic teaching optimization, providing novel technical avenues to overcome the inherent deficiencies of traditional talent training systems [8, 9]. In particular, autonomous intelligent agents featuring active perception, real-time decision-making and iterative optimization align closely with the fast-evolving and interdisciplinary nature of ICV education, creating new opportunities for precise teaching delivery and scenario-based practical training.

Despite these advances, local universities face prominent structural barriers in delivering qualified ICV talent training. Rigid disciplinary segmentation restricts cross-major collaborative teaching, resulting in fragmented curriculum design and incomplete interdisciplinary knowledge systems for students. Existing university–enterprise cooperation remains superficial, with industrial core technologies and practical engineering projects rarely integrated into full-cycle talent cultivation. The limited availability of high-fidelity, engineering-oriented training platforms reduces students' access to complex practical scenarios and undermines their engineering competency development. In addition, standardized teaching practices fail to accommodate personalized learning demands and timely curriculum renewal, leading to a persistent mismatch between graduate competency profiles and industrial employment requirements. The consequent shortage of interdisciplinary ICV professionals has substantially constrained the sustainable advancement of the domestic ICV industry[10].

The technological intelligence empowerment, interdisciplinary boundary penetration and in-depth industry–education integration have become indispensable pathways for advancing ICV talent training within emerging engineering construction. This study develops an original "one subject, two pillars" training framework for ICV talent cultivation. The framework adopts ICV teaching reform as the core orientation, large models as the fundamental technical support, intelligent agents as the dynamic driving engine, and interdisciplinary and industry–education integration as dual collaborative dimensions. This paper elaborates the framework's internal coupling mechanisms and operational logic, and establishes a systematic implementation system for intelligent, interdisciplinary and practice-oriented ICV talent training. The findings offer solid theoretical references and replicable practical models for local universities to optimize emerging engineering education paradigms and address the structural shortage of high-quality interdisciplinary talents.

2. Industrial Requirements and Practical Predicaments of ICV Talent Cultivation

2.1. Industry Upgrading and Compound Talent Shortage

Intelligent connected vehicles and vehicle–infrastructure cooperation represent strategic emerging industries defined by cross-disciplinary integration and multi-technology innovation. The industrial technical system covers vehicle control, environmental perception, intelligent decision-making, V2X communication, traffic optimization and network safety, forming an interconnected and systematic technical chain. The commercialization of high-level autonomous driving has reshaped industrial talent demands, shifting recruitment focus from single-skilled technicians to versatile engineers with systematic thinking and integrated innovation competence.

The domestic ICV industry suffers from prominent structural talent deficits. Existing practitioners commonly possess fragmented knowledge backgrounds. Vehicle engineering professionals often lack algorithmic capabilities, communication personnel lack systematic traffic cognition, and technical researchers are insufficiently experienced in practical engineering implementation. The scarcity of interdisciplinary talents with systematic industrial vision and project practice experience hinders industrial technological iteration and upgrading. Such industrial changes urgently require educational transformation to bridge the gap between disciplinary training and industrial practical demands.

2.2. Educational Transformation and Institutional Constraints

Emerging engineering education reform emphasizes interdisciplinary integration and industry–education collaboration to adapt higher engineering training to industrial innovation. The ICV field, as a typical interdisciplinary engineering scenario, closely matches the core orientation of emerging engineering construction. Traditional university training, however, relies on rigid disciplinary division, leading to isolated majors, fixed curriculum frameworks and bounded faculty allocation. These institutional limitations restrict cross-domain knowledge teaching and adaptive talent cultivation, resulting in a structural lag industrial technological progress.

Modern ICV education requires comprehensive transformation across four dimensions: from disciplinary segmentation to interdisciplinary integration, from classroom indoctrination to scenario-based practical training, from closed campus education to industrial collaborative cultivation, and from standardized teaching to personalized ability development. Conventional educational technologies and institutional mechanisms cannot accommodate such transformative requirements. Manual resource scheduling, fragmented university–enterprise interaction and delayed curriculum iteration further weaken training effectiveness, and maintain a persistent mismatch between graduate competencies and industrial job expectations.

3. Theoretical Framework and Implementation System of AI-Enabled ICV Talent Cultivation

3.1. Theoretical Framework

This study develops an integrated “one subject, two pillars” talent training framework based on emerging engineering education standards, ICV industrial demands and digital higher education trends. The framework regards ICV teaching reform as the core orientation, large models as the underlying technical foundation, intelligent agents as the dynamic driving engine, and interdisciplinary and industry–education integration as dual collaborative pillars. These four components form a tightly coupled operational system. Teaching reform defines overall training objectives; large models provide systematic knowledge and data support; intelligent agents enable full-process teaching optimization; dual integration mechanisms facilitate students’ knowledge construction and engineering competence improvement.

This framework clarifies hierarchical functional positioning for all constituent elements, which distinguishes it from fragmented traditional reform modes. It resolves common defects in conventional educational practices, including ambiguous reform orientation, scattered resource allocation and insufficient iterative capacity. The established paradigm features directional guidance, solid technical support, dynamic empowerment and collaborative quality improvement.

Teaching reform functions as the core subject dominating the overall design and implementation of talent cultivation. All AI-enabled teaching optimization, interdisciplinary penetration and industrial collaborative training center on the cultivation of compound ICV talents. Targeting existing defects in curriculum design and practical teaching, this core subject coordinates technical application, scenario expansion and industrial resource integration. It ensures that all reform practices conform to emerging engineering cultivation standards and industrial talent demands. As shown in Figure 1, the framework of the One-Body-Two-Wings talent training system is structured as follows.

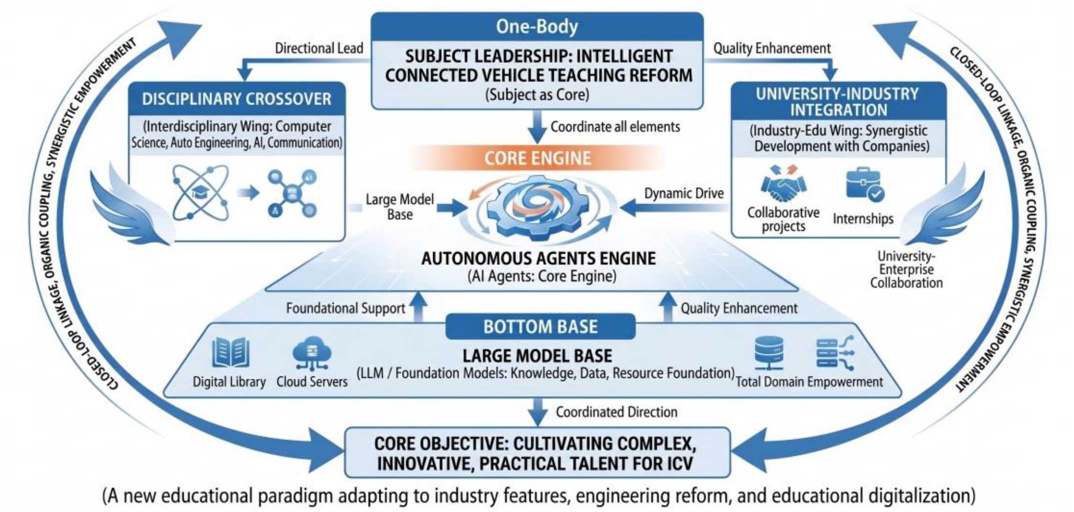

Figure 1: The framework of One-Body-Two-Wings talent training system.

Large models constitute the fundamental supporting layer of the proposed system. Equipped with powerful cross-domain knowledge integration and data analysis capabilities, large models systematically sort interdisciplinary knowledge systems, track industrial technological updates, mine learning data and allocate educational resources. These functions provide stable, comprehensive and iterative technical support for curriculum optimization, student ability assessment and industry–education resource matching, and lay a reliable data and knowledge foundation for intelligent teaching reform.

Intelligent agents serve as the core dynamic engine for system operation. Unlike the static resource support provided by large models, intelligent agents enable dynamic teaching execution, scenario expansion and closed-loop optimization. They construct personalized teaching scenarios, connect industrial resources and simulate complex engineering environments, converting static technical resources into actionable teaching momentum. This mechanism effectively addresses low collaboration efficiency, insufficient practical scenarios and inadequate personalized adaptation in traditional teaching modes.

Interdisciplinary integration and industry–education integration act as dual developmental pillars of the system. Interdisciplinary integration breaks disciplinary segmentation and reconstructs systematic knowledge frameworks to strengthen students' compound theoretical literacy. Industry–education integration embeds industrial technologies, engineering projects and occupational standards into teaching procedures, transforming theoretical accumulation into practical engineering problem-solving capabilities. The coordination of the two pillars realizes dual improvement of knowledge system and practical competence, and supports high-quality ICV talent cultivation.

The four-layer structural system presents rigorous hierarchical logic and interactive coupling relationships. Clear functional positioning and interdependent operation resolve the logical chaos and element fragmentation of traditional educational reforms. It establishes a standardized and intelligent training paradigm for high-quality ICV talent cultivation.

3.2. Closed-Loop Operation and Systematic Implementation Paths

As shown in Figure 2, this section establishes a systematic five-dimensional closed-loop operational mechanism centering on subject leadership, technical empowerment, engine driving, dual-pillar collaboration and dynamic optimization. Oriented by high-quality compound talent cultivation goals, the mechanism guides full-cycle reforms covering curriculum iteration, practical teaching upgrading and faculty competency development.

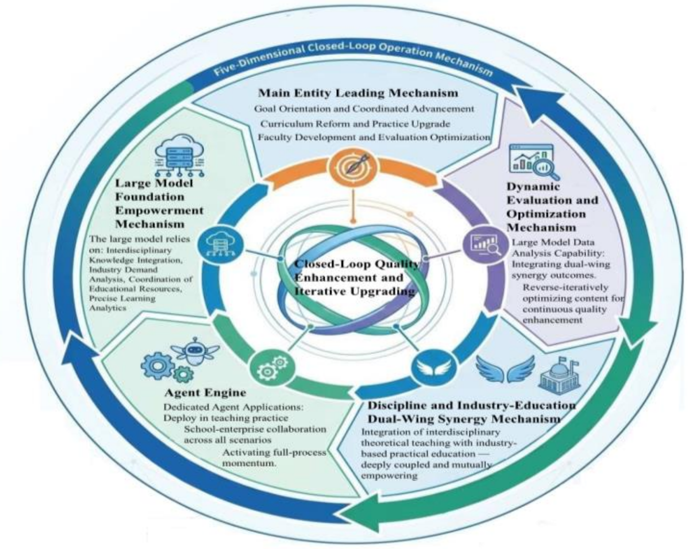

Figure 2: Five-dimensional closed-loop operational mechanism.

Large model technologies enable precise industrial demand assessment and cross-disciplinary educational resource coordination, while intelligent agents support the whole-process iteration of personalized teaching scenarios and staged practical training schemes. The dual integration of interdisciplinary disciplines and university–industry resources effectively breaks traditional disciplinary segmentation and closed campus teaching boundaries, constructing an open and collaborative educational operation paradigm. Dynamic evaluation modules collect real-time teaching data and learning feedback to realize continuous system tuning, structural optimization and effect verification, forming a self-circulating and sustainable upgrading mechanism. This rigorous closed-loop operational logic resolves the defects of scattered reform measures, discontinuous implementation and lack of iterative feedback in conventional educational practices, providing standardized operational norms for AI-enabled ICV talent cultivation reform. Anchored in this theoretical framework and operational logic, the study delivers multi-dimensional systematic implementation paths that fully operationalize each functional module of the closed-loop mechanism for standardized and normalized educational reform.

Subject leadership and technical empowerment jointly underpin institutional innovation and curriculum system optimization, which serve as the fundamental support for orderly system operation. Relying on large model knowledge integration and data analysis capabilities, a dedicated interdisciplinary collaborative platform aggregates multi-disciplinary teaching resources, identifies implicit deficiencies in traditional teaching procedures, and dynamically adjusts talent training schemes, achieving standardized and orderly coordination of cross-domain teaching content and progress. Intelligent agent-driven university–industry linkage mechanisms further embed industrial core technologies, engineering projects and professional competency standards into university teaching systems, transforming fragmented short-term cooperation into stable, long-term and mutually beneficial collaborative cultivation modes. Guided by such intelligent collaborative mechanisms, the overall talent training objectives are revised to adapt to interdisciplinary industrial characteristics, and a hierarchical modular curriculum system is constructed, covering general education, disciplinary foundation, professional core courses, interdisciplinary directional modules and innovative practical training. Centering on the full ICV technical chain, targeted interdisciplinary curriculum groups are set up to eliminate disjointed knowledge points and repetitive teaching contents. Large model-enabled dynamic updating mechanisms synchronize curriculum knowledge, typical teaching cases and practical engineering projects with cutting-edge industrial technologies, ensuring the timeliness, systematicness and practicality of teaching content. Meanwhile, multi-dimensional intelligent evaluation and incentive systems are formulated to cover interdisciplinary teaching quality, university–industry cooperation effectiveness and AI teaching innovation outcomes. Quantitative assessment indicators and targeted incentive policies effectively stimulate teachers' initiative in participating in intelligent and interdisciplinary teaching reforms, fostering a positive ecological environment for sustained educational iteration.

Dual-pillar collaboration further facilitates in-depth university–industry integration and hierarchical practical teaching upgrading, which complements and enriches the practical implementation dimension of the closed-loop mechanism. This study bridges the gap between campus theoretical instruction and industrial engineering practice through intelligent scenario construction and whole-process practical training iteration. The university cooperates with leading ICV enterprises to build high-fidelity intelligent training platforms, introducing professional industrial equipment, intelligent simulation tools and authentic engineering resources to construct immersive and scenario-based practical teaching environments. Intelligent agents assist enterprise senior engineers in conducting remote guidance, real-time case analysis and procedural teaching demonstration, effectively compensating for the scarcity of on-campus practical resources and single training scenarios. Following the progressive learning logic from basic cognition, comprehensive application to innovative exploration, a complete practical cultivation chain is established, including basic experiments, comprehensive design, intelligent simulation training, scientific research innovation, enterprise internships and discipline competition training. AI technology accurately matches industrial practical projects and complex technical challenges with different teaching stages, realizing problem-oriented and project-driven hierarchical training. The university–industry joint evaluation mechanism integrates multi-source data of classroom learning, practical operation and innovative practice to implement full-process quality monitoring, ensuring the pertinence and effectiveness of practical talent cultivation.

Dynamic optimization and sustainable system iteration rely on high-quality faculty teams and comprehensive literacy cultivation, which guarantee the long-term effective operation of the entire training system. This study strengthens compound faculty team construction and embeds comprehensive literacy cultivation into the whole talent training process to underpin high-quality intelligent interdisciplinary education. The university builds specialized interdisciplinary teaching innovation teams, and establishes normalized enterprise practical training and AI teaching competency training systems to continuously improve teachers' industrial engineering experience and digital teaching capabilities. External senior enterprise engineers and technical experts are recruited as part-time instructors to form a complementary university–industry faculty structure, which significantly improves the overall capacity of interdisciplinary and practical teaching. In terms of comprehensive literacy cultivation, engineering ethics, innovative thinking, team collaboration awareness and professional responsibility are embedded in all links of curriculum teaching, practical training and innovative activities. Industrial scenario-based teaching strengthens students' professional identity and innovative mission in the ICV field. AI-enabled academic atmosphere construction further guides students to actively participate in interdisciplinary learning and engineering innovation practice, realizing integrated cultivation of professional knowledge, engineering practical capabilities and comprehensive professional literacy. The coordinated advancement of the above implementation paths forms a complete closed-loop iteration logic from institutional guarantee, curriculum implementation, practical empowerment to quality optimization, enabling continuous improvement of ICV intelligent talent cultivation systems.

4. Reform Values and Future Research Prospects

4.1. Reform Effects and Demonstration Value

Training Quality and Disciplinary Development Improvement: The proposed training mode optimizes students' interdisciplinary knowledge structure and enhances their systematic thinking, intelligent tool application and engineering innovation capabilities. The reform improves student performance in discipline competitions and innovative practices, and strengthens graduates' occupational adaptability and employment competitiveness. Corresponding educational construction promotes the formation of stable interdisciplinary teaching and research teams, accelerates curriculum iteration and enriches high-quality teaching achievements. It significantly improves the connotation construction and social service capacity of ICV-related disciplines.

Collaborative Ecology and System Maturity Enhancement: AI-enabled intelligent docking mechanisms upgrade traditional sporadic university–enterprise cooperation into in-depth, stable and systematic collaborative cultivation. Platform co-construction, joint training and cooperative research realize precise linkage between education, talent, industry and innovation chains, forming a mutually beneficial collaborative ecology. Meanwhile, the reform establishes a mature and operable intelligent teaching system covering resource integration, dynamic iteration, precise assessment and full-process empowerment, and promotes the digital and intelligent transformation of emerging engineering education.

Popularization and Demonstration Significance: The proposed training framework features rigorous logicality, high operability and strong replicability. Its reform ideas and implementation paths are applicable not only to ICV talent cultivation, but also to other interdisciplinary engineering fields such as intelligent manufacturing and intelligent transportation. This research provides a reliable practical paradigm for local universities to promote emerging engineering reform and educational digital transformation, and offers valuable references for alleviating structural talent shortages in emerging engineering industries.

4.2. Reform Challenges and Future Optimization Directions

Main Challenges of the Reform Implementation: The implementation of the proposed talent training reform still faces several prominent challenges under the operational context of local universities and the evolving rules of AI and ICV industries. First, AI-empowered teaching evaluation systems remain imperfect. Unified evaluation standards for interdisciplinary intelligent teaching workload and innovative achievements are absent, which weakens teachers' motivation for AI teaching innovation. Second, enterprise collaborative education mechanisms lack mature benefit restraint mechanisms. The imbalance between corporate resource input and practical returns reduces willingness for long-term in-depth educational participation. Third, high-level compound teachers are insufficient. Few faculty members possess interdisciplinary knowledge, front-line engineering experience and AI teaching capabilities simultaneously, which restricts high-quality intelligent interdisciplinary education. Fourth, intelligent practical platforms face sustained operation and maintenance pressure. Imperfect iteration, updating and sharing mechanisms limit the utilization efficiency of high-quality educational resources.

Future Optimization Directions: Targeted at the above challenges, future research will further optimize and iterate the reform framework from four dimensions. First, improve institutional systems for AI-enabled education. Universities should refine the standards for workload recognition, achievement evaluation, and incentive assessment for interdisciplinary intelligent teaching, so as to fully stimulate teachers' innovative enthusiasm. Second, consolidate university–enterprise interest communities. Universities should promote joint enrolment, joint training, cooperative research and joint employment to build stable, long-term collaborative mechanisms featuring shared interests and risks, and thereby fully activate corporate participation in education. Third, strengthen compound faculty introduction and cultivation. Universities should establish normalized platforms for AI teaching training, enterprise practical training and interdisciplinary further education, and introduce high-level interdisciplinary talents in order to optimize the faculty structure. Fourth, optimize the operational mechanism of intelligent practical platforms. Universities should establish long-term university-enterprise mechanisms for resource sharing, technological iteration and joint operation, so as to improve resource utilization efficiency and continuously upgrade talent training modes.

5. Conclusion

This study systematically constructs an innovative "one subject, two pillars" intelligent talent training system, with teaching reform as the core subject, large models as the foundational support, intelligent agents as the driving engine, and dual integration as the developmental pillars. It clarifies the hierarchical structure, internal coupling mechanism and five-dimensional closed-loop operational logic of the system, and proposes a complete set of implementation paths covering intelligent collaboration, curriculum reconstruction, practical empowerment, faculty cultivation and dynamic evaluation. This framework defines clear functional positioning for each core element, and resolves prominent defects in traditional educational reform, including ambiguous reform orientation, element fragmentation, logical disorder and insufficient iterative capacity. It reconstructs a novel ICV compound talent training logic featuring directional guidance, foundational consolidation, dynamic empowerment and collaborative quality improvement.

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