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Exploration on Practical Education Mode of Vehicle Engineering Specialty

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Abstract

The traditional teaching mode of vehicle engineering fails to meet the demand of the industry for innovative talents with comprehensive capabilities. This paper takes the "three-axis linkage" educational model as the core, deepens the integration of industry and education to optimize the practical teaching content, relies on the integration of specialized and creative education to stimulate students' innovative potential, and builds a teaching system that combines general and specialized knowledge, and complements virtual and real-world aspects based on course integration. It forms a new paradigm of practical education centered on students. Taking the production internship of the vehicle engineering major as an example, through project-based learning, collaborative guidance by enterprise mentors, and independent practice, the teaching is transformed from "knowledge imparting" to "ability construction". After the reform, the achievement degree of course goals for the 21st-grade students in the vehicle engineering major has increased by 4% on average compared to the 20th grade. Students' engineering practice ability and innovative thinking have significantly enhanced. The feedback from enterprises on the alignment of internship content with industry demands has improved. All these aspects verify the effectiveness of the "three-axis linkage" model in solving the lagging problem of traditional teaching and improving the adaptability of talents, providing practical references for the new engineering education in universities.

Keywords

Integration of industry and education; specialized integration; curriculum integration; practice education

In recent years, the rapid development of communication technology, sensing technology, and digital technology has propelled the automotive industry into a new phase of "electrification, connectivity, intelligence, and sharing" (Yang Diange, 2021). Today, revolutionary leaps in technology, innovative allocation of production factors, and deep transformation and upgrading at the enterprise level are becoming powerful drivers for the vigorous development of new productive forces. As a key source of technological innovation, universities find that the traditional teaching model of "Vehicle Engineering" can no longer keep pace with the current changes in the industry landscape. Under the broad-based general education framework, universities should identify disciplinary characteristics, align with enterprise needs, and leverage resource advantages. Based on this, they should explore and upgrade the professional practice education model, striving to cultivate high-quality, interdisciplinary new engineering talents with strong practical and innovative abilities and international competitiveness (Wu Yan, 2020). This will help build a channel that aligns the knowledge system of talents with industry demands, continuously empowering new productive forces.

1. Three-axis Linkage Education Reform

Over the past century, advancements in the vehicle industry have predominantly centered on the optimization of mechanical structures and the enhancement of internal combustion engine systems. The advent of the "New Four Modernizations" era has redefined modern automobiles as a synergy of "hardware and software," transitioning their role from mere "transportation devices" to "intelligent mobile spaces." Numerous emerging enterprises have entered the automotive manufacturing sector, leveraging cross-industry resource integration and innovation to propel the industry into a phase of transformative development. According to the "2023 Report on Talent Development in New Energy Vehicles," recruitment demand within the new energy vehicle sector has surged by 32%, with projections indicating a talent shortfall of 1.03 million in China by 2025. In 2024, new energy vehicle sales accounted for 40.9% of total new vehicle sales (Liu Yin, 2025), intensifying competition among enterprises in terms of business strategies, resource allocation, and talent acquisition.

The vehicle engineering discipline falls under the traditional domain of mechanical engineering. The talent cultivation programs in most universities remain focused on knowledge transfer, with teaching content primarily centered around "power systems, mechanical structures, and control systems". The design of the curriculum system fails to align with the current development trends of the vehicle industry, characterized by "mechanical carriers integrated with new energy, information technology, artificial intelligence, and other interdisciplinary fields" (Wu Jingshan, 2022; Liu Ji'an, 2022), particularly in the production practice teaching components. Issues such as an imperfect curriculum framework, insufficient integration of innovation and entrepreneurship training with professional knowledge, inadequate guidance on students' professional ethics and values, and a lack of practical training opportunities have emerged. To address these challenges and align with industry advancements, the "three-axis linkage" practical education model (Figure 1) is proposed. Guided by the "three-learning concept", this model promotes the integration of "industry-education collaboration, specialty-innovation fusion, and curriculum synthesis," systematically resolving existing teaching issues to establish a novel paradigm for vehicle engineering education.

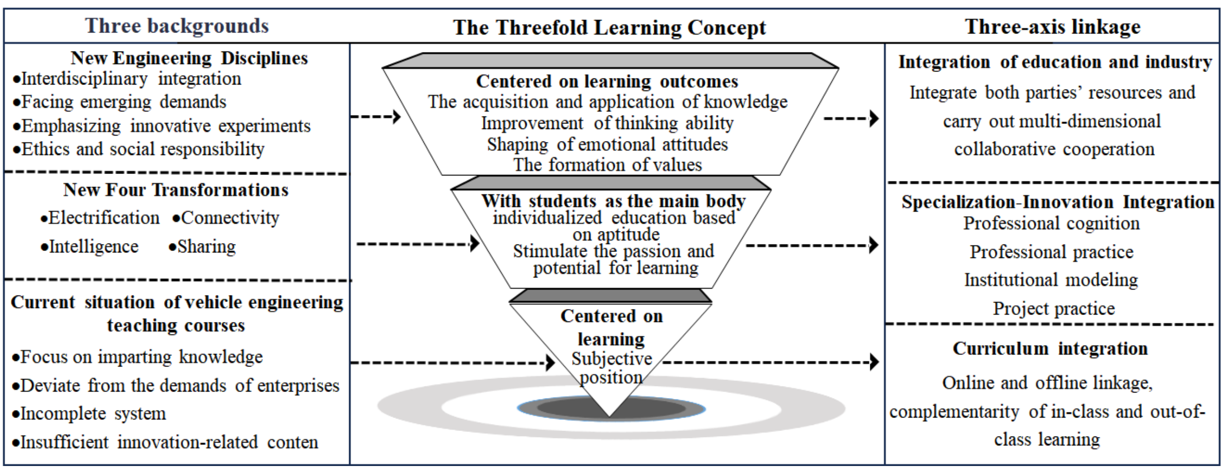

Figure 1. A New Model for Educating Students in Vehicle Engineering.

2. Industry-Education Integration: Bridging the Talent-Industry Gap

The development trends of the vehicle industry and the training directions for vehicle engineering talents are mutually reinforcing. The transformation of the vehicle industry relies on the technological innovation of talents from universities and colleges, and it requires interconnection and communication among multiple links, such as teaching and research in universities. Taking the "Automobile Professional Production Practice" course as an example, the setting of the talent training plan often lags behind the development of industrial demands, and there are problems such as "excessive proportion of traditional technologies, shallow cooperation between schools and enterprises, and outdated design of practical projects". Therefore, it is necessary to jointly build a collaborative teaching mechanism with enterprises and start in-depth teaching integration of industry and education.

The integration of industry and education should foster organic interaction among "institutions, students, and enterprises," leverage regional advantages, and appropriately align the levels of cooperation between industry and academia. Taking North China University of Science and Technology as an example, as a provincially designated key backbone university, it should collaborate with regionally leading enterprises for industry-education integration based on graduate employment trends. This involves integrating the curriculum system, developing textbook frameworks, conducting industry-education integration practices, enhancing faculty development, and constructing a first-class teaching system for industry-education integration. Encourage faculty members to utilize enterprise projects as vehicles to enhance students' engineering practical skills and their ability to address real-world engineering challenges. By relying on the "research-practice platform, teaching-experiment platform, and industry-education integration project," a practical teaching and education model can be established that is "problem-oriented, resource co-built, results shared, project-driven, process co-managed, and innovation win-win." Deep collaboration with automotive enterprises should also be pursued, with internship content tailored to align with corporate production plans and technical requirements.

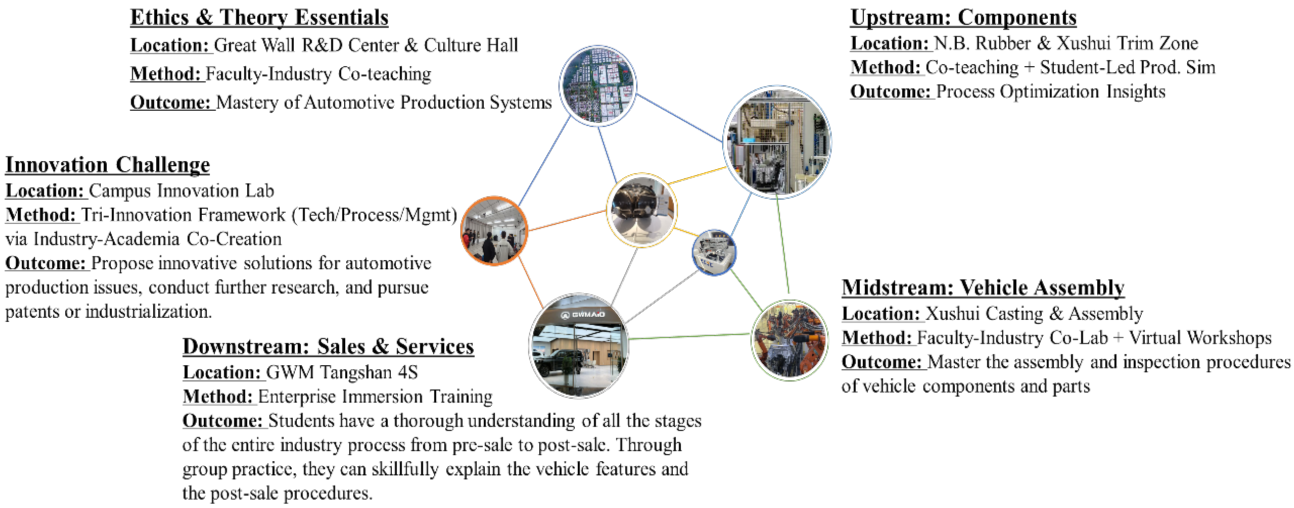

Figure 2. Full-Chain Production Internship Base.

The development of new-type talents emphasizes the enhancement of practical skills, innovation capabilities, and interdisciplinary integration. This trend has increased the requirements for constructing practical education bases within the field of vehicle engineering. The industry-academia collaboration in vehicle engineering employs the "new energy vehicle prototype trial production" project as a case study for practical teaching. Leveraging the comprehensive resources of Great Wall Automobile Factory, an integrated base for research, education, and industry has been established, encompassing three key stages: upstream focuses on component manufacturing and electrical technology; midstream integrates core processes such as stamping, welding, painting, and assembly; downstream extends to automotive marketing and after-sales service networks, while incorporating enterprise human resource management into practical teaching to enhance students' understanding of real-world business practices. This approach ensures that graduates are better equipped to meet societal demands (Li Xin, 2021), as illustrated in Figure 2.

Under the joint guidance of on-campus faculty and enterprise mentors, students address real-world engineering challenges such as "diagnosis of welding defects in white body structures" and "energy storage systems for hydrogen fuel cell vehicles," developing a systematic understanding of Great Wall Automobile's "forest ecosystem oriented by energy and intelligence". Through practical projects, students gain expertise in critical automotive manufacturing technologies and deepen their knowledge of cutting-edge industry advancements. Experienced engineers provide on-site explanations of production processes and operational procedures during internships while guiding hands-on operations.

The achievement level of "Target 1" in the Vehicle Engineering Department's course "Automobile Professional Production Internship" is closely linked to the effectiveness of industry-academia integration. The observation index focuses on "familiarity with the characteristics of the entire process of automotive service technology and various sales methods." Following the implementation of teaching reforms, the average achievement level of Target 1 for Class 1 of Vehicle Engineering 21 increased by 4% compared to Class 1 of Vehicle Engineering 20, with a notable reduction in the disparity among students' achievement levels (Figure 3). This demonstrates that through industry-academia integration, students have achieved significant improvements in their understanding of the industrial chain, gained deeper insights into the latest industry trends, and benefited from more standardized and universally applicable practical teaching sessions.

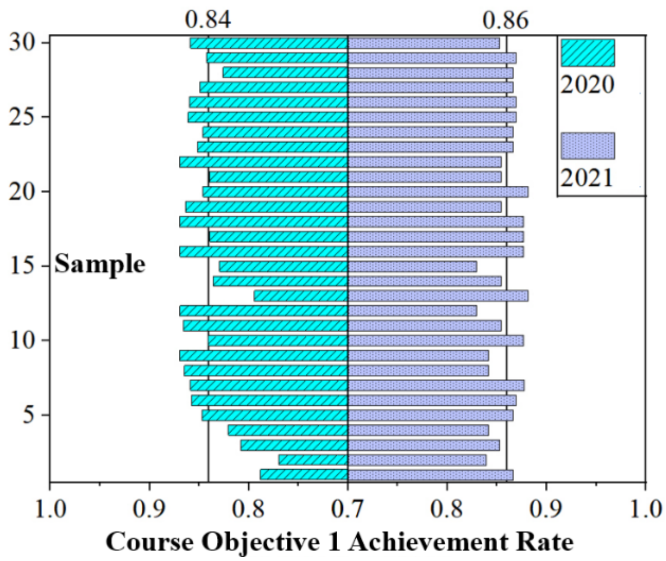

Figure 3. Comparison of Achievement of Course Objective 1.

3. Integrating Specialization with Innovation to Address the Teaching Gap in "Innovation and Entrepreneurship Content"

The ongoing transformation of the automotive industry has further highlighted the pressing need for cultivating high-caliber professionals with interdisciplinary and applied innovative competencies (Zhang Hongxia, 2021). Many universities, constrained by their delayed initiation of entrepreneurship and innovation education as well as insufficient faculty resources, have predominantly treated the development of entrepreneurial and innovative capabilities as an isolated course, failing to achieve effective integration with specialized knowledge. Moreover, since the enhancement of these capabilities is largely reflected in intangible aspects and is challenging to evaluate systematically, students often perceive their engagement in entrepreneurial and innovative practices as discretionary, leading to passive participation. Based on the characteristics of specific disciplines, the integration of professional and innovation education can be categorized into three types: "demand-driven," "technology-driven," and "employment-driven" (Shi Yongchuan, 2024). The integration of professional and innovation education in vehicle engineering falls under the typical technology-driven category, focusing on nurturing students' curiosity through project-based learning and stimulating their intrinsic creativity (Figure 4). Through comprehensive case studies spanning the entire engineering process, students are guided to investigate the interplay between theoretical knowledge and practical application while emphasizing the holistic and developmental nature of problem-solving.

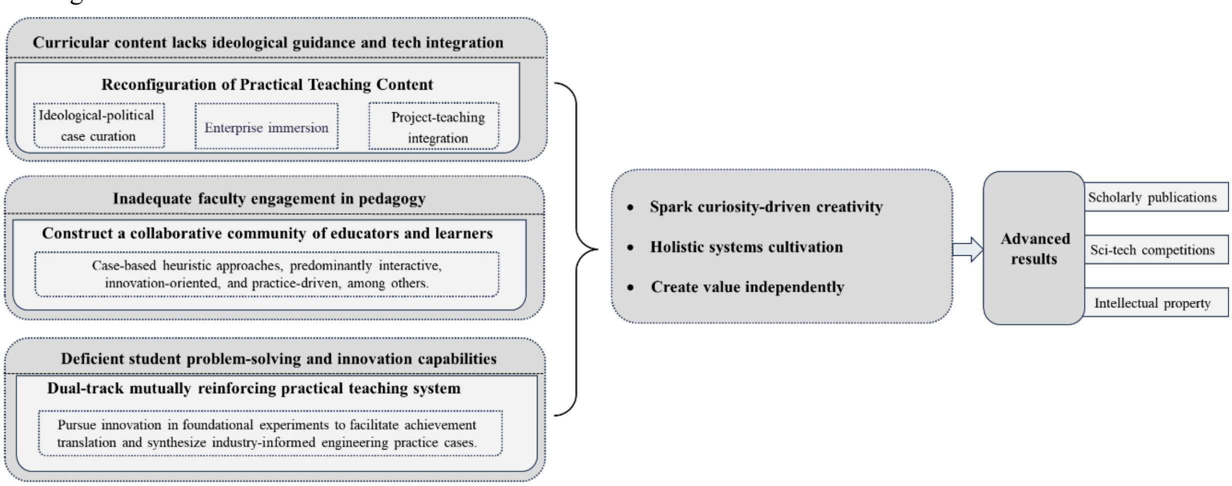

Figure 4. Integration of Specialization and Innovation.

Based on the characteristics of vehicle engineering, a four-layer progressive teaching system for innovation and entrepreneurship practice is established. This includes: "basic practice → professional competence → innovation breakthrough → transformation application" and "industry cognition → project incubation → engineering practice → comprehensive innovation". The system adopts a dual-track approach with mutual promotion. On the experimental track, basic experiments lay the foundation by familiarizing students with fundamental principles and operations; professional experiments deepen knowledge application in specialized areas; innovation experiments encourage creative thinking and breakthroughs; and the transformation application layer integrates knowledge and research capabilities through comprehensive evaluation. On the practical training track, cognitive practice introduces students to industry and positions; project incubation enhances the integration of theory and practice; engineering practice provides hands-on experience in real-world production environments; and comprehensive innovation fosters cross-disciplinary knowledge reconstruction through multi-dimensional resources such as engineering case libraries, innovation and entrepreneurship case libraries, and simulation case libraries. These resources integrate scientific research achievements from the experimental track with engineering experience from the practical training track, enabling the construction of an entire vehicle industry innovation framework from concept design to prototype development and after-sales service. A dynamic data-sharing mechanism connects the two tracks, using experimental data to optimize practical parameters and engineering feedback to refine experimental models, forming a closed-loop system of "theoretical validation →practical testing → iterative improvement". With the support of online learning platforms, representative courses are integrated online and offline, promoting complementary in-class and extracurricular innovation and entrepreneurship practices. This enhances the construction of an innovation and entrepreneurship course cluster while cultivating students' innovative thinking and practical application skills.

Evaluation combines process-based assessment with outcome-oriented evaluation, examining both the rigor of experimental reports and the market feasibility of practical projects. Through joint defense with enterprises, three-dimensional verification of knowledge, ability, and quality is achieved. For example, during automotive assembly internships, students undertake the "optimization of automotive engine assembly processes" project, analyzing existing procedures, proposing improvements, and validating feasibility through simulated assembly. Ideological and political cases are incorporated into practical training to guide students in establishing correct values, linking personal growth with national development, and contributing to strategic emerging industries and key technology breakthroughs.

Teaching reform has resulted in a 4% increase in the average achievement of course goals 2 and 3 for the 21st-grade Vehicle Engineering Class 1 compared to the 20th-grade class (Figure 5). Surveys indicate that most students can articulate insights about the future automotive industry based on real-world cases and plan their career paths accordingly. The integration of specialized and innovative education has stimulated students' enthusiasm for innovation and entrepreneurship, encouraging them to participate in science and technology competitions and develop skills in market research, product design, and marketing planning, laying a solid foundation for future careers or entrepreneurial endeavors.

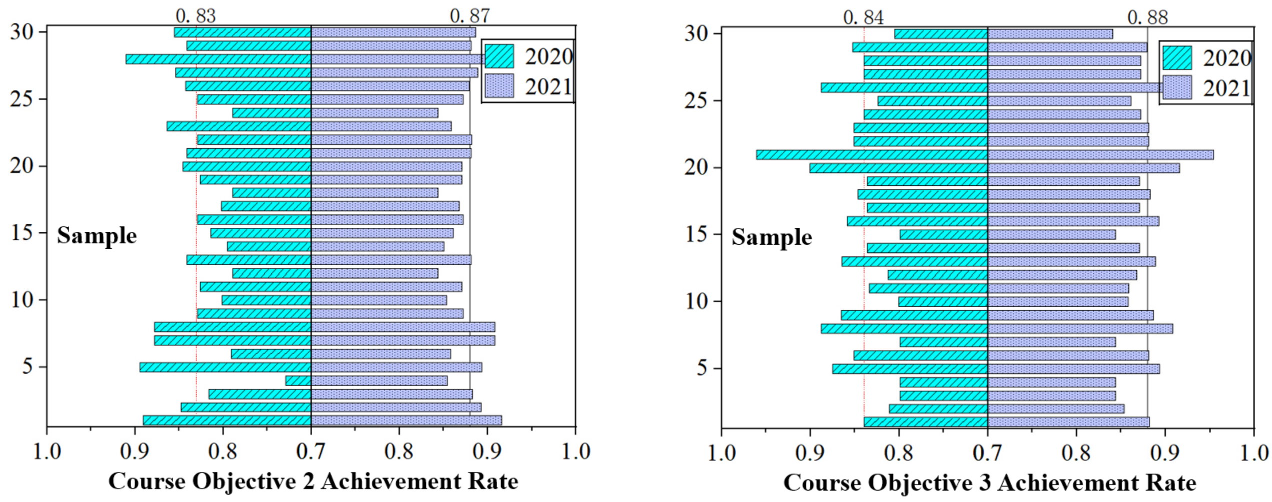

Figure 5. Comparison of Achievement of Course Objectives 2 and 3.

4. Curriculum Integration Enhances the Teaching System

We adopt "heuristic, interactive, and guiding" teaching methods, reconstruct the curriculum system of "general education courses → basic professional courses → professional module courses → cutting-edge discipline courses → integrated courses of innovation and entrepreneurship", and integrate the concepts of green, high-end, and intelligent into it. In the general education layer, strengthen interdisciplinary contents such as mathematical modeling and introduction to artificial intelligence; in the basic professional layer, on the basis of the course of Mechanical Design Foundation, add core knowledge such as vehicle big data analysis and principles of new energy power systems; in the professional module layer, on the basis of the traditional power module, add two branch modules of intelligent networking and new energy vehicles; in the discipline cutting-edge layer, introduce cutting-edge knowledge such as autonomous driving algorithms and hydrogen energy technology; in the integrated innovation and entrepreneurship layer, construct a three-level progressive system of "creative inspiration - virtual simulation - industrial incubation", and create a specialized and innovative course group and three-dimensional resources that are linked online and offline and complementary inside and outside the classroom to cultivate students' basic theoretical and practical application abilities. We should integrate "three-dimensional textbooks, virtual simulation experiments, engineering case libraries, ideological and political cases, and simulation cases" into the vehicle teaching system, and build a multi-dimensional knowledge architecture.

In terms of educational resource integration, construct a "paper textbooks + digital resources" three-dimensional teaching system. Each chapter of the textbooks embeds dynamic QR codes that link to the three-dimensional model library, engineering animations, and explanation videos. Students can view complex mechanical structures such as the internal oil flow path of the engine cylinder block and the gear meshing process of the transmission gear through mobile scanning.

In terms of curriculum ideological and political construction, develop a "curriculum materials library for the development history of the automotive industry" to tell the history of China's automotive industry from scratch to strength, and tell the stories of the older generation of automotive people overcoming numerous difficulties and independently developing domestic automobiles. This will stimulate students' national pride and patriotic feelings and cultivate their spirit of hard work. Combine industry hot events, such as China's leading breakthroughs in the international field of new energy vehicles, to discuss the institutional advantages and the spirit of scientists behind scientific and technological innovation, guiding students to establish correct worldviews, outlooks on life, and values, and firmly believe in the belief of serving the country through science and technology.

In simulation case teaching, introduce classic design cases of well-known car manufacturers to analyze their design concepts, target customer group demand research, design process of appearance and interior, and application of ergonomics. Through the analysis of classic design cases, stimulate students' learning interest and deepen their understanding of the process and methods of vehicle design. Design "simulation case of intelligent connected vehicle development", combining multiple disciplines such as computer science and electronic information, covering aspects such as simulation of environmental perception algorithms, simulation of on-board communication systems, and construction of decision control models.

5. Conclusion

In the face of the development trend of "New Four Modernizations" in the vehicle industry and the lag of traditional teaching models in universities, this paper proposes the "three-axis linkage" practical education model. Through deepening the integration of industry and education, the integration of specialized and innovative education, and the integration of courses, it effectively solves the problems of disconnection between the cultivation of vehicle engineering professionals and industrial demands, the lack of innovation and entrepreneurship content, and the imperfect teaching system. Practice has proved that this model significantly enhances students' engineering practical ability, innovative thinking, and professional quality. The " three-axis linkage " practical education model not only provides a new idea for the cultivation of talents in the vehicle engineering major but also offers a reference example for the educational reform of other majors under the background of new engineering disciplines. In the future, efforts will be made to actively promote the construction of regional industry-education alliances, focus on exploring the participation paths of small and medium-sized enterprises, and enhance the cooperation stickiness of enterprises through policy guidance, resource integration, and benefit-sharing mechanisms. A database for tracking the five-year career development of graduates will be established to quantitatively evaluate the long-term impact of teaching reforms and establish a dynamic feedback mechanism, providing empirical support for the iterative optimization of the practical education model for vehicle engineering.

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