An Industry-Demand-Driven Cultivation Model of Automotive Excellent Engineers: Reform and Practice of Intelligent Vehicle Testing Course

Xiongshi Wang, Yonghui Wang, Meng Li, Bian Gong, Hongnan Wang, Heyan Li, Shupeng Zhang*

College of Urban Transportation and Logistics, Shenzhen Technology University, Shenzhen, Guangdong, China

**Corresponding Author*

Abstract: With the development of the "New Four Modernizations" (Electrification, Intelligence, Networking, and Sharing) in the automotive industry, traditional vehicle engineering talent training models face severe challenges, such as the teaching content is outdated, the practical abilities are weak, and the industry-education integration is insufficient. In particular, the significant shortage of interdisciplinary talents in the field of intelligent vehicle testing has become a bottleneck restricting industrial development. This study takes the teaching reform of the "Intelligent Vehicle Testing Technology" course at Shenzhen Technology University as an example. It is guided by industry demands, and a "trinity" practical teaching system is built, which is integrated "in-class practice, project-driven learning, and industry-education collaboration." By optimizing course content, co-building off-campus practice bases, and introducing real enterprise testing projects, these measures have effectively enhanced students' engineering practice abilities, interdisciplinary integration skills, and innovative thinking. Mid-term results show a significant increase in course enrollment, high completion rates of student projects, and notable achievements in academic competitions. This reform provides a replicable and scalable pathway for cultivating outstanding automotive engineers who meet the industrial demand.

Keywords: Industry Demand; Outstanding Engineer; Intelligent Vehicle Testing; Practical Teaching; Industry-Education Integration

1. Introduction

The global automotive industry is currently undergoing a profound transformation centered on "electrification, intelligence, connectivity, and sharing." Intelligent connected vehicles (ICVs) have become a strategic emerging industry in China. The *Outline for Building a Power Nation in Transportation* issued by the Ministry of Transport explicitly states the need to strengthen the R&D of intelligent connected vehicles and form a self-reliant and controllable complete industrial chain [1]. However, a widening gap persists between rapid industrial evolution and traditional engineering talent cultivation. According to recent data from Zhaopin, with the rapid transition of the automotive industry toward the "New Four Transformations," the demand for high-skilled talent in the industry has increased significantly. As shown in Figure 1, the top 10 positions with the fastest growth in hiring numbers in the automotive industry from January to July 2023, the high-tech content engineers account for 8 positions. Among them, process engineers and test engineers rank first and second with year-on-year growth rates of 25% and 20%, respectively [2]. According to relevant data from the China Society of Automotive Engineers, the net shortage of R&D talent in China's intelligent connected vehicle industry will reach 13,000 to 37,000 people by 2025, with an even larger gap in high-skilled talent [3]. Enterprises urgently need "outstanding frontline engineers" who not only understand traditional automotive technology, but also master interdisciplinary knowledge such as artificial intelligence, big data, communication and possess strong engineering practical abilities.

The traditional talent cultivation models in vehicle engineering face several critical issues: (1) Outdated course content that lags behind the rapidly evolving frontier technologies in intelligent vehicle testing [4].

(2) The practical teaching link is weak, students lack training in solving problems in real, complex engineering environments, resulting in a disconnect between theory and practice [5,6].

(3) University-enterprise cooperation is superficial, and a long-term mechanism for enterprises to deeply participate in the entire talent training process has not yet been formed [7,8]. Therefore, exploring an industry-demand -oriented cultivation model for automotive excellent engineers has become an urgent priority for higher education reform.

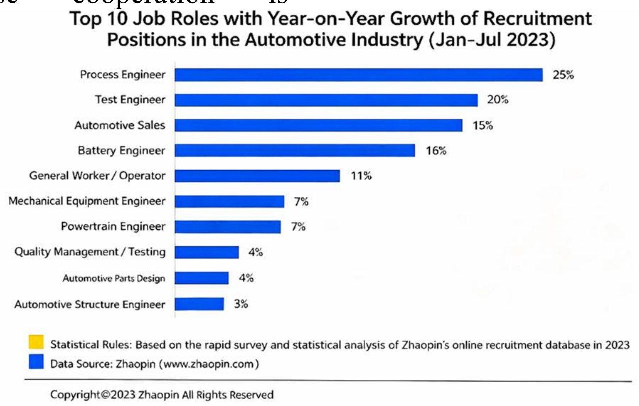

Figure 1. Top 10 Positions with the Fastest Growth in Recruitment Postings in the Automotive Industry (January–July 2023)

As an application-oriented university, Shenzhen Technology University adheres to the educational path of "industry-education integration and school-enterprise cooperation". Relying on its College of Urban Transportation and Logistics, this study takes the *Intelligent Vehicle Testing Technology* course as a starting point to implement practice-oriented teaching reform driven by industrial needs, aiming to build a cultivation system that effectively enhances students' engineering practice and innovation capabilities, thereby supplying high-quality excellent engineers to the automotive industry.

2. Construction of an Industry-Demand -Oriented Practical Teaching System

To address the pain points of traditional teaching, this reform project closely aligns with the real needs of the ICV industry in Shenzhen and the Guangdong-Hong Kong-Macao Greater Bay Area [9,10,11], systematically constructing a practical teaching system for the *Intelligent Vehicle Testing Technology* course. This system forms a "three-in-one" cultivation model comprising "In-class Practice, Project-driven Learning, and School-enterprise Collaboration." Figure 2 illustrates the architecture of the industry-demand-oriented experimental teaching system for intelligent vehicle testing.

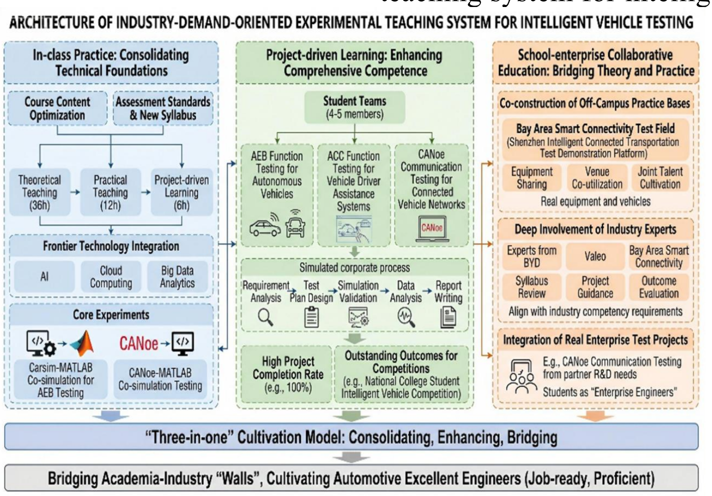

Figure 2. Industry-Demand-Oriented Experimental Teaching System Architecture for Intelligent Vehicle Testing Technology

2.1 In-Class Practice: Consolidating Technical Foundations

The project team first comprehensively optimized the course content. The new syllabus clearly defines assessment standards across three major modules: theoretical teaching (36 credit hours), practical teaching (12 credit hours), and project-driven learning (6 credit hours). The course content was promptly updated with the incorporation of frontier technologies such as artificial intelligence, cloud computing, and big data analytics, with a focus on strengthening practical aspects closely related to the industry, such as virtual simulation testing, communication and network security testing. The project team systematically restructured the in-class practice components, aiming to establish a capability cultivation chain that bridges fundamental theories to tool applications, and from single skills to systematic cognition. This was advanced through the following three dimensions:

(1) Dynamically updating experimental content in alignment with the industry technology stack. For the rapid technological iteration and frequent toolchain updates in intelligent vehicle testing, the teaching team, in collaboration with enterprise technical experts, thoroughly overhauled the existing experimental projects. The two newly established core experiments — "Carsim-Matlab Co-simulation for AEB Testing" and "CANoe-Matlab Co-simulation Testing"—are directly benchmarked against the current mainstream development and testing toolchains in the industry. The experimental guides not only retain foundational content such as the classical TTC (Time to Collision) algorithm and PID control but also incorporate advanced modules, including scenario construction for extreme conditions based on scenario libraries and sensor noise injection. This enables students to engage with testing methodologies and analytical workflows that are synchronized with frontline industrial practices, effectively narrowing the tooling gap between campus learning and job practice.

(2) Strengthening data-driven thinking through integration into the entire intelligent testing analysis workflow. In-class practice is no longer confined to software operation and functional verification; rather, it adopts "data acquisition-feature extraction-result interpretation-anomaly attribution" as the core thread of competence development. In the AEB simulation experiment, students are required not only to build control models and execute simulations but also to perform statistical analysis on time-series data, including longitudinal acceleration, collision warn- ing timing, and braking intervention time, and to evaluate the algorithm’s robustness under complex scenarios such as rain, fog, backlighting, and so on. Through such training, students are progressively established with evidence-based and data-driven decision-making mindsets in testing, laying methodological foundations for subsequent processing of massive real-vehicle road test data.

(3) Designing tiered progressive tasks to balance foundational consolidation and exploratory innovation. To accommodate the diverse needs of students with varying learning backgrounds, each in-class experiment was designed with a three-tiered task progression: "a basic verification layer, a comprehensive application layer, and an extended challenge layer." The basic layer requires students to reproduce the testing process under standard conditions and complete standardized reports; the comprehensive layer introduces multi-parameter coupling or changes in boundary conditions, requiring adjustments to testing strategies; the extended layer encourages students to independently design comparative experiments or introduce improved algorithms to optimize and verify the test results. This tiered design ensures that all students have a solid grasp of basic testing skills while providing space for in-depth exploration for those with extra capacity, effectively stimulating innovation in in-class practice.

2.2 Project-Driven Learning: Enhancing Comprehensive Abilities

Project-driven learning serves as a critical bridge connecting in-class skills with industrial practice. The project team conducted refined design across three dimensions—project selection, organizational workflow, and evaluation mechanisms—to ensure students achieve systematic capability advancement through the complete project cycle.

(1) "Real problems with real solutions" in

project selection, closely addressing the actual testing pain points of enterprises. The three core projects (AEB function testing, ACC function testing, and CANoe network communication testing) are all derived from the real testing needs of partner companies during the R&D verification phases and are transformed into standardized project task books after being adapted for teaching purposes. Each project is accompanied by the original test requirement documents, real-vehicle data segments, and reference acceptance standards provided by the enterprise, enabling students to face real technical constraints from the very beginning of the project as "quasi-engineers"—including limited testing time windows, imperfect sensor data, and common boundary abnormalities in engineering. This "real problems with real solutions" model effectively solves the problems of simplified task scenarios and evaluation standards that are out of touch with reality in traditional project-based teaching.

(2) Full-cycle team collaboration, simulating enterprise agile testing iterations. Students are organized into teams of 4–5 members, with clear division of labor as test design engineer, simulation execution engineer, data analysis engineer, and project leader, and advance the project according to the common enterprise process of "requirements review - test case design - simulation execution - defect submission - regression verification". During the intensive project cycle of 6 class hours, each team needs to complete at least two rounds of iterative optimization: the first round is to execute tests based on the initial plan and submit a list of issues, and the second round is to adjust the test boundaries or supplement the working conditions for the exposed abnormal results, re-execute tests, and compare the differences between before and after. This process not only cultivates students' team communication and task coordination skills but also enables them to deeply understand the core methodology of "iterative progression and gradual approximation" in engineering testing.

(3) Multi-subject joint evaluation, emphasizing process performance and engineering standards. Project assessment no longer relies solely on a single simulation report for grading; instead, it constructs a three-dimensional evaluation system of "process data + result quality + defense performance". Process data includes the team's task submission records, test version change logs, and issue-tracking forms in the project management system, used to assess work standardization and collaboration efficiency; result quality is quantitatively scored based on engineering indicators such as test coverage, anomaly detection rate, and result reproducibility; the defense session invites enterprise technical experts and course instructors to form a review panel to interrogate the engineering rationality of test strategy selection, anomaly attribution logic, and improvement suggestions. This multi-subject evaluation mechanism not only strengthens students' awareness of engineering documentation standards and quality closure, but also provides a window for enterprises to identify and select outstanding reserve talents in advance.

2.3 School-Enterprise Collaborative Education: Bridging Theory and Practice

Deep industry-education integration is the core support and key breakthrough of this reform. The College of Urban Transportation and Logistics at Shenzhen University of Science and Technology fully utilizes Shenzhen's unique geographical advantages as a "Silicon Valley" in China and a highland for the intelligent connected vehicle industry in the Greater Bay Area, adopting multi-level, all-round school-enterprise collaborative education strategies:

(1) Co-construction of Off-Campus Practice Bases: Relying on the industrial resources of Pingshan District, an off-campus internship and training base was established in partnership with the "Bay Area Smart Connectivity Test Site" (Shenzhen Intelligent Connected Transportation Test Platform), clearly clarifying the responsibilities of "equipment sharing, venue sharing, and talent co-education". The base is equipped with advanced testing facilities and simulation platforms, providing students with valuable opportunities to experience the entire process of real vehicle testing, enabling a leap from classroom simulation to real-world test tracks.

(2) Deep Involvement of Industry Experts in Curriculum Development: Technical experts from enterprises such as BYD, Valeo, and Bay Area Smart Connectivity were invited to review the teaching syllabus, guide projects, and evaluate outcomes, ensuring that the

course objectives align precisely with industry job competency requirements (e.g., the skills requirements for "Intelligent Driving Assistance System Test Engineers" in the *Pingshan District of Shenzhen New Energy and Intelligent Connected Vehicle Industry Urgently Needed Talent Catalog*). In the project-driven phase, real corporate cases and evaluation criteria are introduced to ensure that teaching content is closely aligned with industry needs.

(3) Integration of Real Enterprise Testing Projects: To address the issue of "fake problems with fake solutions" or "fake problems with real solutions" in traditional teaching, the project team extracts teaching cases from the actual R&D needs of partner enterprises, transforming real enterprise testing tasks into core projects for the course. For example, the core project in the course "Intelligent Connected Vehicle Network Communication CANoe Testing" directly originates from the actual needs of the partner enterprise for testing the interference and stability of in-vehicle CAN bus signals. Students need to built Matlab/Simulink models like enterprise engineers, simulate sending and receiving bus messages by CANoe software, and write test sequences for automated analysis.

In summary, through the "three-in-one" cultivation model of "in-class practice, project-driven learning, and school-enterprise collaboration" and the school-enterprise collaborative education strategies of "platform co-construction, faculty sharing, and joint project research," this reform has successfully broken down the "walls" between schools and industries, fully integrating industry standards, advanced equipment, and real projects into the entire teaching process. This not only makes the "Intelligent Vehicle Testing Technology" course as an important bridge connecting students and industries, but also lays a solid practical foundation for cultivating outstanding automotive engineers who are "ready to work immediately and excel quickly."

3. Implementation Effects and Outcome Analysis

Since the project was launched in January 2025, all reform measures have been progressed smoothly according to the plan and have achieved significant phased results, strongly verifying the effectiveness of the new training model.

3.1 Students' Practical Abilities Have Been Significantly Enhanced, with a Broad Beneficiaries

The most direct outcomes of the reform are reflected in students' comprehensive abilities and learning enthusiasm. In the fall semester of 2025, the course had 120 enrolled students, with an increase of 36% compared to 88 before the reform. In project-based teaching, students are required to comprehensively apply sensor principles, control theory, simulation software, and programming knowledge, significantly strengthening their interdisciplinary integration skills and problem-solving abilities. Student teams, supported by off-campus practice bases, have successfully assisted the school's Formula SAE racing team in completing a real vehicle testing project, with a total of over 20 hours of experiments. Students experienced the entire iterative optimization process from simulation data to real-vehicle performance, greatly deepening their understanding of the "testing" concept and achieving a closed loop from theory to practice.

3.2 Initial Success of Industry-Education Integration Platforms and Positive Interaction

Collaborations with the Greater Bay Area Intelligent Connected Vehicle Test Site, Xingyun New Energy Technology (Shenzhen) Co., Ltd, BYD, and other enterprises have progressed from intention to implementation. Both parties have signed an internship and training base agreement, specifying equipment sharing, personnel exchanges, and project cooperation. The enterprises not only provide students with practical internship opportunities but also bring their actual needs and technical challenges in the testing field into the classroom, guiding the continuous iteration and updating of course content and project design. For example, the "CANoe Communication Testing for Intelligent Connected Vehicle Networks" project closely aligns with the job competency requirements for onboard network (CAN/LIN/Ethernet) testing engineers. This "real project, real practice" mode enables students to engage with industrial frontline issues during their studies, significantly enhancing their employability.

3.3 Simultaneous Upgrading of Teaching Resources and Faculty Competence

To support the new teaching model, the project team has completed three core experimental project guides and built a project repository based on real enterprise cases. By participating in teacher training, enterprise research, and exchange cooperation with domestic and foreign universities such as TU Berlin, the interdisciplinary integration ability and engineering practical guidance ability of teachers have been enhanced. The project team has also undertaken multiple provincial and university-level teaching reform and research projects, forming a well-structured, industrially experienced teaching team that is comprised of professors, associate professors, senior experimentalists, and assistant professors.

4. Conclusions and Recommendations

Taking the course reform of *Intelligent Vehicle Testing Technology* at Shenzhen Technology University as a case study, this paper systematically elaborates on the exploration and practice of an industry-demand-oriented cultivation model for automotive excellent engineers. Practice has demonstrated that constructing a "three-in-one" practical teaching system integrating "in-class practice, project-driven learning, and school-enterprise collaboration" effectively resolves core challenges in traditional engineering education, such as disconnected theory-practice, outdated content, and superficial industry-education integration. This model not only significantly enhances students' engineering practice capabilities, interdisciplinary integration skills, and innovative thinking but also provides a replicable paradigm for application-oriented universities to align with emerging industrial demands and cultivate urgently needed high-quality talent.

To further deepen this talent cultivation model, future improvements may focus on the following aspects:

(1) Establish a Dynamic Curriculum Update Mechanism: Form a curriculum guidance committee composed of industry experts and university teachers, which regularly (e.g., every six months) reviews and updates the curriculum content to keep it in line with the rapid iteration of intelligent connected vehicle technology.

(2) Develop a Deep Practice Platform Integrating Virtual and Real Environments: Further increase investment to build an "Intelligent Vehicle Testing Full-Process Practice Center" that integrates real vehicle test tracks, hardware-in-the-loop simulation, and digital twins, providing students with seamless practical experiences from model-in-the-loop to vehicle-in-the-loop.

(3) Improve the Long-term Mechanisms of School-enterprise Collaboration: Explore the establishment of "community of interests" between schools and enterprises, transforming enterprise participation in talent cultivation from short-term actions into stable, long-term strategic cooperation through joint industrial academies, collaborative horizontal research projects, and scholarships, thereby achieving an organic integration of the education chain, talent chain, industrial chain, and innovation chain.

Acknowledgments

This study was funded by [2025 Teaching Reform Project of Shenzhen Technology University – "Research on Practical Teaching Reform of Intelligent Vehicle Testing Course for Cultivation of Automotive Excellent Engineers" (No. 20251025); 2024 Shenzhen Educational Science Planning Project—"Research on 'Three-linkage, Two-step, Integrated' Talent Cultivation Model for Intelligent Vehicle Technicians" (No. ZDZZ24014)]. The authors sincerely thank [Heyan Li, Professor] for valuable discussions and technical support. We also appreciate the assistance provided by [Intelligent Vehicle Laboratory, Shenzhen Technology University].

References

[1] Liu H. D., Lu X. Empowering with Digital Intelligence to Promote High-Quality Development of Urban Transportation – A Record of the Pilot Project for Building a Strong Nation in Sustainable Urban Transport System Research. Transport Construction & Management, 2024(6): 40-42.

[2] Xie S. M., Que H. B. An Analysis of the Path to Building Application-Oriented Undergraduate Program Clusters from the Perspective of Industrial Clusters – A Case Study of the Automotive Engineering

Program Cluster at J College. Automotive Knowledge, 2024, 24(12): 155-160.
[3] China Society of Automotive Engineers. Intelligent Connected Vehicle Industry Talent Demand Forecast Report. Beijing: Beijing Institute of Technology Press, 2021.
[4] Nie, Z. G., Chen, Z., & Wang, W. Q. Exploration of teaching reform in intelligent vehicle control technology direction for vehicle engineering major. Journal of Higher Education, 2022, 8(12): 128-132.
[5] Wang, J. P., Xiao, P, & Gao, H, et al. Research on implementation status, problems, and countermeasures of "Excellent Engineer Cultivation Plan" in vehicle engineering major. Education and Teaching Forum, 2019(32): 103-105.
[6] Wang, H .L., Pi, D. W., & Wang, X. H., et al. Exploration and practice of school-enterprise joint cultivation for excellent engineers in vehicle engineering major . Journal of Higher Education, 2023, 9(27): 1-4.
[7] He, B. Q, Liang, Y. Y., & Li, X. F., et al. Exploration of professional course construction and reform for "excellent front-line engineer" education cultivation. Innovative Education Research, 2022, 10(4): 851-857.
[8] Li, H. J., Zhao, X. H., & Cheng, J., et al. Design and teaching application of miniature intelligent vehicles for intelligent transportation practice courses. China Educational Technology & Equipment, 2024(18): 32-37.
[9] Zeng X. H., Niu C. H., Chen X. M. Suggestions on Further Promoting the High-Quality Development of China's New Energy Vehicles. Automobile & Parts, 2024(17): 56-58.
[10] Zhao J. G. Automotive Industry Shifts Toward Clustering and Integrated Development. China Automotive News, 2025-12-22 (006).
[11] Editorial Board of the Guangdong Province New Energy Vehicle Technology Innovation Roadmap. Guangdong Province New Energy Vehicle Technology Innovation Roadmap. China Machine Press: 2023.