

Research on a tiered project-based learning and process-oriented assessment model for the intelligent automotive industry: evidence from a specialized class in electronic information engineering

*Tao Zheng**, *Yuanshuai Lan*, *Min Luo*

Geely University of China, China

zhengtao@guc.edu.cn

Abstract. Against the backdrop of the rapid development of the intelligent automotive industry, this study addresses the challenges of weak industry–education integration and static evaluation systems in engineering talent cultivation at local application-oriented universities by proposing and validating a novel training model integrating school–enterprise collaboration and tiered project-driven learning. Using a specialized pilot class in Electronic Information Engineering at Geely University as a case study, a three-dimensional collaborative education ecosystem comprising cross-boundary campuses, cross-regional campuses, and parallel campuses was established. A progressive three-stage engineering project framework, ranging from foundational scenario-based experiences to authentic enterprise Research and Development (R&D) tasks, was implemented, and a five-dimensional radar-chart-based dynamic evaluation model grounded in process-oriented assessment was developed to align student competency development with the talent requirements of leading automotive enterprises. Quantitative results demonstrate that the proposed model achieved 100% participation in intellectual property outputs among students in the pilot class and a 50% award rate in disciplinary competitions. Furthermore, a bidirectional selection mechanism based on dynamic digital competency profiles enabled 13 students to be successfully admitted to internship programs at Geely Group. The findings provide a data-driven and practically validated approach for innovating engineering education paradigms oriented toward the intelligent automotive industry.

Keywords: engineering education reform, integration of industry and education, project-based learning, process-oriented dynamic assessment

1. Introduction

With the rapid development of emerging industries such as artificial intelligence, new energy vehicles, and intelligent manufacturing, engineering positions have placed increasingly high demands on graduates' knowledge structure, practical competence, and innovation capability. In particular, within the intelligent automotive industry, key technologies such as intelligent cockpits, domain controllers, in-vehicle electronic

systems, and thermal management systems are undergoing continuous iteration and upgrading. This evolution has led to a sustained demand for interdisciplinary and application-oriented talent who possess a solid foundation in electronic information engineering, coupled hardware–software development capability, and the ability to solve complex engineering problems. Against this backdrop, constructing a talent training system aligned with industrial development has become a critical issue in the reform of engineering education in higher education institutions [1, 2].

In recent years, China has continuously promoted the construction of "New Engineering Education" and the integration of industry and education, emphasizing that universities should deepen school–enterprise collaborative education mechanisms and promote the organic integration of the education chain, talent chain, industry chain, and innovation chain, thereby improving the quality of applied talent cultivation [3, 4]. Meanwhile, international engineering education reform has increasingly demonstrated trends characterized by Outcome-Based Education (OBE), Project-Based Learning (PBL), and collaborative innovation. These approaches advocate integrating authentic engineering scenarios, interdisciplinary practice, and industry participation throughout the talent cultivation process to enhance students' capability to solve complex engineering problems and their professional adaptability [5–7].

Extensive research has been conducted both domestically and internationally on engineering education reform. In terms of training models, studies have shown that deep school–enterprise cooperation can effectively promote the sharing of practical teaching resources and improve students' engineering practice competence and employability [8]. In curriculum reform, project-driven and task-driven teaching models have been widely applied in disciplines such as electronic information engineering, computer science, and intelligent manufacturing, enabling students to enhance their comprehensive design and teamwork abilities through real-world projects [9]. In terms of evaluation systems, an increasing number of studies have focused on process-oriented assessment and competency profiling, emphasizing the use of digital technologies to continuously record students' learning behaviors and practical performance, thereby providing a more comprehensive basis for competency evaluation and talent development [10, 11].

Despite these achievements, several limitations remain. First, existing school–enterprise collaboration models are mostly concentrated on co-developed courses or graduation internships, while cases of deep enterprise participation throughout the full undergraduate training process based on real R&D projects remain limited. Second, many project-based teaching reforms focus on individual courses or localized practical modules, lacking a progressive, multi-year project system spanning the entire undergraduate stage, which leads to fragmentation in competency development pathways. Third, most current evaluation systems still rely primarily on course grades or staged outcomes, with insufficient systematic and dynamic assessment of students' engineering design capability, teamwork, innovation ability, and continuous improvement capacity developed through long-term project practice. As a result, these systems struggle to meet enterprises' needs for precise identification of engineering talent. Therefore, constructing a talent cultivation model that integrates school–enterprise collaboration, tiered project-based training, and process-oriented competency evaluation remains an important research direction.

Based on this context, this study takes the specialized Electronic Information Engineering class at Geely University as a practical case. Considering the talent demands of the intelligent automotive industry, a school–enterprise collaborative, tiered project-driven talent cultivation model oriented toward industrial practice is explored and implemented. This model constructs a multi-stakeholder collaborative education environment, designs a progressive project system spanning the entire four-year undergraduate program, and establishes a process-oriented evaluation mechanism based on engineering competency profiling, thereby effectively aligning talent cultivation, competency assessment, and enterprise requirements. Compared with regular

classes and previous cohorts, students in the pilot program achieved notable practical outcomes in intellectual property generation, discipline competitions, and enterprise internship recruitment. Among them, 33 students achieved full coverage of intellectual property outputs, and several students entered partner enterprises for internships, providing a practical reference for applied universities to advance engineering education reform oriented toward the intelligent automotive industry.

The main contributions of this paper are summarized as follows: (1) a school–enterprise collaborative education pathway oriented toward the intelligent automotive industry is constructed, promoting deep integration between university educational resources and real industrial engineering scenarios; (2) a tiered project system covering the entire undergraduate training process is designed, enabling a progressive development of students' engineering competencies; and (3) a process-oriented evaluation mechanism based on engineering competency profiling is established, providing a novel approach for student competency assessment and enterprise talent selection, with its feasibility and applicability validated through a case study of a specialized class.

2. Design of a school–enterprise collaborative and tiered project-driven talent cultivation system

2.1. Overall framework of the cultivation system

To address key issues in the training of Electronic Information Engineering students oriented toward the intelligent automotive industry—such as insufficient practical engineering scenarios, fragmented project structures, and overly simplified competency evaluation systems—this study proposes a talent cultivation system characterized by "school–enterprise collaboration, tiered project-driven learning, and process-oriented assessment support." The system is designed based on the principles of industry-demand orientation, progressive competency development, and full-process collaborative education.

Driven by authentic engineering requirements from the intelligent automotive industry, the system integrates university curricula, enterprise practical resources, and student competency evaluation mechanisms into an organically connected framework, forming a closed-loop training pathway spanning the entire four-year undergraduate program, as illustrated in Figure 1.

The proposed system consists of three core components. First, a multi-stakeholder collaborative education ecosystem is constructed, in which universities, partner enterprises, and digital learning platforms jointly support students' practical skill development. Second, a tiered project system aligned with students' cognitive and competency development stages is designed, progressively connecting foundational practice, system integration, and real enterprise R&D tasks to achieve stepwise engineering capability enhancement. Third, a process-oriented evaluation mechanism based on engineering competency profiling is established to continuously record students' practical performance, providing evidence for curriculum improvement, academic advising, and enterprise-based talent selection.

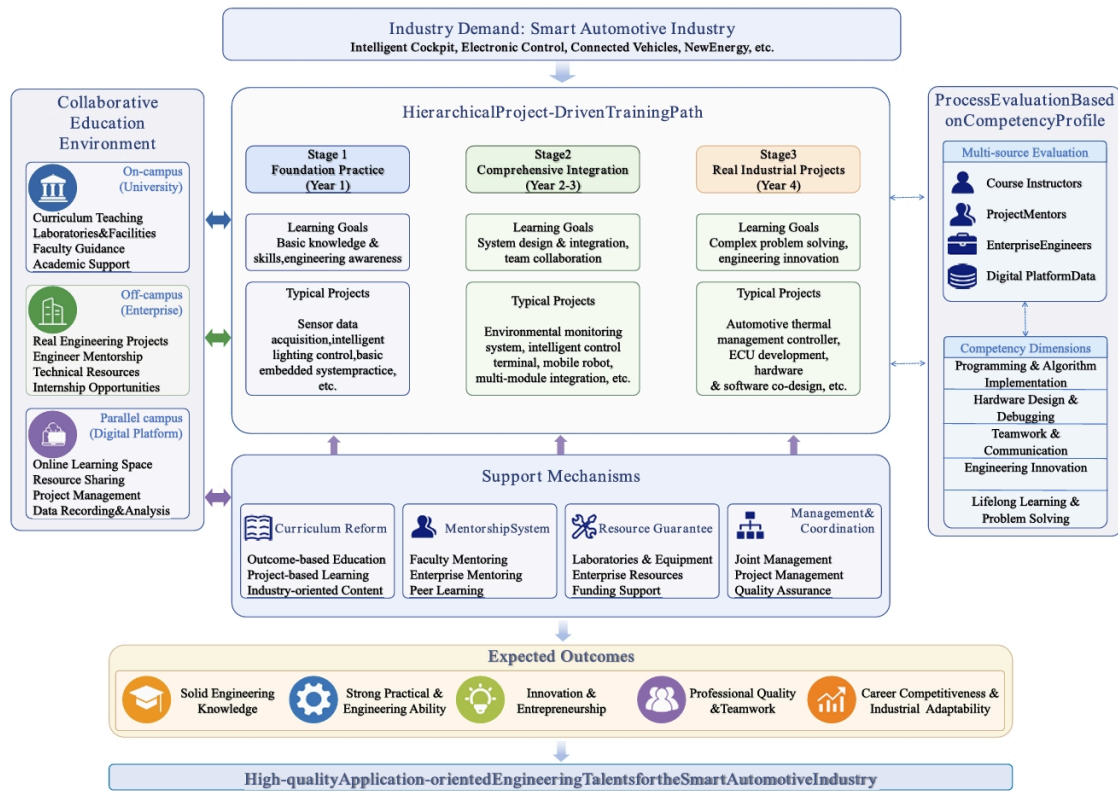


Figure 1. Framework of the school–enterprise collaborative and tiered project-driven talent cultivation system

2.2. Construction of the school–enterprise collaborative education environment

To improve alignment between talent cultivation and industrial requirements, this study builds a collaborative education environment supported by a school–enterprise cooperation platform, integrating physical campuses, enterprise practice platforms, and digital learning spaces.

During the on-campus training stage, universities are primarily responsible for theoretical instruction, fundamental laboratory training, and professional competency development. Through curriculum reform and laboratory platform construction, students are provided with a solid foundation in electronic information engineering. In parallel, partner enterprises open selected R&D projects, engineering cases, and technical resources to students, with enterprise engineers participating in practical guidance. This enables students to engage with authentic product development processes and industry standards.

Beyond traditional school–enterprise cooperation, the research team actively leverages digital teaching platforms and AI-assisted tools to construct an online learning environment. This environment provides project documentation, technical materials, online mentoring, and collaborative knowledge-sharing functions, effectively extending learning beyond the classroom. Through the integration of these heterogeneous resources, a complementary multi-subject ecosystem is established to jointly support the development of students' engineering practice capabilities.

2.3. Tiered project-driven training pathway

Based on the staged progression of students' knowledge structures and competency development, this study designs a three-stage project-based training pathway covering the entire undergraduate period, enabling a

progressive transition from "fundamental training" to "comprehensive practice" and finally to "real-world engineering development."

The first stage targets first-year students and focuses on foundational engineering competency development. By integrating courses such as electronic technology and programming design with typical automotive electronic application scenarios, basic projects such as in-vehicle sensor data acquisition and intelligent lighting control systems are developed. Through circuit design, software development, and hardware debugging exercises, students establish preliminary engineering awareness and acquire fundamental hardware–software co-design skills.

The second stage covers second- and third-year students and focuses on complex system integration. Under a combination of team-based project organization and instructor guidance, students are encouraged to develop comprehensive projects such as environmental monitoring systems, intelligent control terminals, and mobile robotic platforms. During this stage, students gradually master key technologies including modular system design, embedded system development, communication protocol application, and multi-module integration debugging, thereby strengthening their system-level engineering design and teamwork capabilities.

The third stage is designed for students with strong disciplinary foundations and innovation potential. Under joint supervision from universities and enterprises, students participate in authentic enterprise R&D tasks. Based on real engineering projects such as new energy vehicle thermal management controllers, students engage in hardware circuit design, motor drive control, embedded software development, and system verification. Through solving complex engineering problems in real industrial contexts, students further enhance their professional competencies and achieve a transition from academic project learning to industrial engineering practice.

2.4. Implementation mechanism of the cultivation system

To ensure the effective implementation of the proposed system, a four-in-one operational mechanism integrating "course teaching, project practice, mentor guidance, and enterprise participation" is established.

At the curriculum level, practical projects are systematically aligned with professional courses to ensure mutual reinforcement between theoretical knowledge and project tasks. At the mentorship level, university instructors are responsible for theoretical guidance and research training, while enterprise engineers participate in project evaluation and technical consultation, jointly promoting competency development.

At the resource support level, open laboratories, innovation practice platforms, and enterprise R&D resources are provided to ensure continuous access to practical training conditions for students. At the outcome-oriented level, project outputs, discipline competition achievements, intellectual property outcomes, and enterprise practice performance are incorporated into the training process, thereby strengthening students' innovation awareness and engineering practice capabilities.

Through this integrated mechanism, students progressively complete knowledge acquisition, engineering practice, research innovation, and professional competency development throughout their undergraduate studies, achieving effective alignment between talent cultivation and industry needs and laying a solid foundation for the subsequent construction of an engineering competency evaluation system.

3. Construction of a process-oriented evaluation system driven by engineering competency profiling

3.1. Design philosophy of the evaluation system

Traditional engineering education evaluation systems primarily rely on course examination scores, periodic laboratory reports, or capstone project outcomes. Such approaches pay insufficient attention to the developmental process of students' competencies during long-term practical training, making it difficult to comprehensively reflect their engineering practice ability, innovation capacity, and teamwork competence. In particular, under school–enterprise collaborative training models, students often participate in projects with long development cycles and diverse task types. Consequently, relying solely on summative evaluation fails to capture students' overall competence realistically and cannot adequately support enterprise-based talent selection.

To address these limitations, this study develops an engineering competency profiling-based evaluation system oriented toward the intelligent automotive industry. The system embeds process-oriented assessment throughout the entire talent cultivation process and adheres to the principles of "full-process recording, multi-dimensional evaluation, and dynamic updating." The evaluation results are not only used for course assessment and training quality improvement but also serve as important references for enterprise mentors in project selection and internship recommendation, thereby strengthening the alignment between talent cultivation and industrial demand.

3.2. Indicator system for engineering competency profiling

Based on the training objectives of the Electronic Information Engineering program, competency requirements of enterprise job positions, and characteristics of student participation in project practice, a five-dimensional engineering competency profiling model is constructed. The model includes: programming and algorithm implementation ability, hardware design and debugging ability, teamwork and communication ability, engineering innovation capability, and continuous learning and problem-solving ability.

Programming and algorithm implementation ability primarily assesses students' embedded programming proficiency, coding standards, and algorithm implementation skills. Hardware design and debugging ability focuses on evaluating circuit design competence, hardware integration debugging, and fault analysis capability. Teamwork and communication ability examines students' performance in project organization, task allocation, and communication/reporting processes. Engineering innovation capability is assessed based on innovative project design, intellectual property outcomes, and participation in disciplinary competitions. Continuous learning and problem-solving ability reflects students' capacity for self-directed learning, solution optimization, and iterative improvement when addressing complex engineering problems.

The evaluation process adopts a multi-stakeholder approach involving course instructors, project mentors, and enterprise engineers. By integrating multi-source data such as project outputs, practical records, competition performance, and innovation achievements, a comprehensive and dynamically updated engineering competency profile is established for each student.

3.3. Implementation mechanism of process-oriented evaluation

The formation of engineering competency profiles is embedded throughout the entire undergraduate training process and aligned with the tiered project-based learning pathway.

During the foundational competency development stage, continuous records are established based on course experiments, programming assignments, and hardware implementation tasks to assess students' basic practical skills. In the comprehensive project practice stage, the evaluation scope expands to system design capability, teamwork performance, and cross-module integration skills. At this stage, mentor evaluations and milestone project assessments are incorporated to update competency profiles.

In the enterprise-based real project stage, evaluation further integrates feedback from enterprise engineers, providing a comprehensive assessment of students' engineering professionalism, project execution capability, and ability to solve complex engineering problems during real R&D tasks.

Compared with traditional summative assessment approaches, this mechanism emphasizes the trajectory of competency development and practical performance. It enables early identification of deficiencies in the training process and provides evidence-based support for personalized guidance and optimization of training strategies.

3.4. Application of engineering competency profiling in talent cultivation

Engineering competency profiles are not only an essential component of student academic evaluation but are also widely applied in innovation practice organization, research project selection, and enterprise internship recommendation.

Within the university training process, instructors utilize competency profiles to assign research training tasks and project roles more appropriately, guiding students toward practical activities aligned with their developmental strengths. In industry–university collaboration, partner enterprises can leverage long-term competency data to gain a more comprehensive understanding of students' engineering experience and overall quality, thereby improving internship matching and talent selection accuracy.

Practical implementation indicates that the process-oriented evaluation model based on engineering competency profiling enhances students' initiative in participating in project-based learning and promotes continuous improvement in innovation capability and engineering practice competence. It also strengthens the alignment between higher education evaluation systems and enterprise competency requirements, offering a new pathway for school–enterprise collaborative education.

3.5. Effectiveness analysis of the training model

To evaluate the effectiveness of the proposed training model, this study selects 33 students from a specialized Electronic Information Engineering class as the research sample and conducts a longitudinal analysis of intellectual property outputs, disciplinary competition performance, and enterprise internship participation. The results are compared with those of regular classes and previous cohorts.

The findings indicate that, under the support of the school–enterprise collaborative system and tiered project-driven mechanism, all students in the experimental class participated in intellectual property development activities, demonstrating significantly higher engagement in innovation practice. In terms of disciplinary competitions, students achieved higher award rates in programming contests, electronic design competitions, and innovation and entrepreneurship competitions compared with those in regular classes. Regarding enterprise practice, multiple students successfully obtained internships in partner companies, demonstrating strong job adaptability and engineering practice competence.

It should be noted that these results are derived from a single case study of a specialized class and may be influenced by factors such as students' baseline academic levels, instructor engagement, and the depth of enterprise collaboration. Future research should incorporate larger sample sizes and multi-year longitudinal data to further validate the generalizability and scalability of the proposed training model.

4. Effectiveness and discussion of the training model

4.1. Research subjects and data sources

This study takes 33 students from the 2023 cohort of the specialized class in the Electronic Information Engineering program at Geely University as the research subjects to conduct a longitudinal analysis of the effectiveness of the school–enterprise collaborative and tiered project-driven training model.

The research data are primarily derived from multiple sources, including statistical records of students' innovation achievements, disciplinary competition performance, enterprise practice participation, and competency evaluation results collected throughout the training process. In addition, comparative data from regular classes and previous cohorts are incorporated to conduct a comparative analysis, as shown in Table 1, in order to comprehensively evaluate the effectiveness of the implemented reform measures.

Table 1. Comparison of key indicators for the implementation effectiveness of the training model

Evaluation Indicators	Featured Class	Regular Classes
Intellectual Property Output Coverage	100%	< 5%
Award Rate in Disciplinary Competitions	50%	13%
Selection Rate for Geely Group Internship Program	39.4%	10.6%

It should be noted that due to differences in cohort size and training conditions across academic years, this study mainly adopts descriptive statistical methods to analyze the training outcomes, with a particular focus on the developmental trends of students' engineering practice competence and innovation capability.

4.2. Improvement in innovative practice capability

In terms of innovative practice, the specialized class adopts a project-driven research training approach, integrating intellectual property cultivation throughout the entire process of course learning and engineering practice. Students are guided to engage in patent applications, software copyright registration, and innovative design activities based on project outcomes.

Statistical results indicate that all 33 students in the specialized class participated in intellectual property development activities, forming a fully inclusive innovation practice mechanism. Compared with traditional training models in which innovative outputs are typically concentrated among a small proportion of students, the integration of school–enterprise collaboration and project-driven learning significantly expands student participation in research and innovation activities, and enhances their abilities in problem identification, problem analysis, and problem solving.

Furthermore, through project implementation, students gradually develop a comprehensive understanding of the transformation process from technical implementation to research output commercialization, laying a solid foundation for future academic research and professional development.

4.3. Analysis of disciplinary competition performance

Based on the tiered project system, students continuously engage in practical training in areas such as electronic design, programming development, and embedded systems during coursework. Project outcomes are further extended into various disciplinary competitions.

Compared with students in regular classes, those in the specialized class demonstrate higher levels of participation and improved award rates in competitions such as the Blue Bridge Cup, Electronic Design

Contest, and innovation and entrepreneurship competitions. In particular, in domains such as programming, embedded development, and intelligent control, the integration of project-based practice and competition training has established a strong synergistic mechanism, enabling students to effectively transfer theoretical knowledge to practical engineering problem-solving scenarios.

These results suggest that real-world project-driven learning can significantly enhance students' comprehensive application of knowledge and improve the relevance and effectiveness of practical engineering education.

4.4. Analysis of enterprise practice and job adaptability

Enterprise practice serves as a critical indicator for evaluating the effectiveness of engineering education reform. By introducing real enterprise R&D tasks, students are exposed during their undergraduate studies to product development workflows, technical standards, and team collaboration models, thereby cultivating engineering awareness and professional competence in practical contexts.

During the training process, several students from the specialized class successfully obtained internships in partner enterprises and participated in R&D tasks related to new energy vehicle electronic control systems. Feedback from enterprises indicates that these students demonstrate strong adaptability in areas such as embedded system development, hardware debugging, and team communication, and are able to integrate into engineering teams and complete assigned tasks efficiently within a short period.

Further analysis based on competency profiling reveals that students who consistently participate in tiered project-based learning and perform well in dimensions such as innovation capability and teamwork capability tend to have a more competitive advantage in enterprise internship selection. This suggests that process-oriented evaluation results can, to some extent, reflect students' engineering practice competence and provide valuable multi-dimensional references for both universities and enterprises in talent cultivation and job matching.

4.5. Discussion

The implementation results of this study indicate that the school-enterprise collaborative and tiered project-driven talent cultivation model effectively promotes the comprehensive development of students' engineering practice ability, innovation capability, and professional competence. On the one hand, by integrating real industrial requirements into curriculum teaching and project practice, the model achieves effective alignment between knowledge acquisition and engineering application. On the other hand, the progressive project system spanning the entire undergraduate stage enables students to gradually develop from foundational skill acquisition to complex system development through continuous practice.

Meanwhile, the process-oriented evaluation mechanism based on engineering competency profiling strengthens data accumulation and feedback during the training process, enabling instructors to more accurately understand students' competency development trajectories. It also provides enterprises with multi-dimensional references for talent selection, thereby enhancing alignment between university training objectives and industrial job requirements.

However, several limitations of this study should be acknowledged. First, the research sample is limited to a single specialized class within one major, resulting in a relatively small sample size. Second, the observed outcomes may be influenced by factors such as students' initial academic level, the depth of enterprise collaboration, and instructor engagement. Therefore, the generalizability of the results still requires further validation through multi-institutional, multi-disciplinary, and longitudinal studies. Future research should

expand the sample size, introduce more comprehensive quantitative indicators, and incorporate long-term tracking data to further investigate the sustained effectiveness of the proposed training model.

5. Conclusion

In the context of the rapid development of the intelligent automotive industry and the emerging demand for application-oriented engineering talent, this study takes the specialized class of the Electronic Information Engineering program at Geely University as a practical case. Focusing on school–enterprise collaborative education mechanisms, tiered project-based learning pathways, and an engineering competency profiling evaluation system, this research explores and constructs an integrated talent cultivation model characterized by "school–enterprise collaboration, tiered project-driven learning, and process-oriented assessment," and further analyzes its implementation effectiveness.

The results indicate that by introducing authentic enterprise engineering scenarios and establishing a multi-stakeholder collaborative education mechanism, the proposed model effectively integrates curriculum teaching, practical training, and industrial requirements. The tiered project system organizes practical activities according to students' developmental stages, promoting a progressive enhancement of foundational knowledge acquisition, system integration capability, and complex engineering problem-solving ability. Meanwhile, the engineering competency profiling-based process-oriented evaluation mechanism strengthens dynamic tracking of students' competency development, providing strong support for personalized training and joint evaluation between universities and enterprises.

From the perspective of practical outcomes, students in the specialized class achieved positive results in intellectual property generation, participation in disciplinary competitions, and enterprise-based practice, demonstrating that deep school–enterprise cooperation combined with project-driven learning plays a significant role in enhancing engineering practice competence and innovation capability. In addition, process-oriented evaluation data show practical value in student competency identification, instructor guidance, and enterprise-based job matching, offering new insights for applied universities to further advance engineering education reform.

Compared with existing studies, the main contributions of this work are as follows: (1) a school–enterprise collaborative training framework integrating universities, enterprises, and digital learning environments is constructed in response to the talent demands of the intelligent automotive industry; (2) a tiered project-driven system covering the entire undergraduate training process is designed, enabling the progressive development of engineering competencies; and (3) an engineering competency profiling-based evaluation mechanism oriented toward long-term student development is established, exploring application pathways of process-oriented assessment in talent cultivation and enterprise recruitment. These practices provide a reference case for applied universities in reforming Electronic Information Engineering and related programs.

Nevertheless, several limitations should be acknowledged. First, the study is based on a single specialized class from one institution, and the limited sample size restricts the generalizability of the findings. Second, the research mainly adopts case study analysis and descriptive statistics, and more rigorous quantitative evaluation methods remain to be further developed. In addition, factors such as enterprise collaboration depth, individual student differences, and instructor engagement may also influence the observed outcomes. Future research should expand the sample scale, incorporate multi-institutional validation and longitudinal tracking data, and apply more comprehensive quantitative indicators and statistical methods to further investigate the long-term effectiveness and scalability of the proposed model.

Overall, the proposed integrated talent cultivation system—combining school–enterprise collaboration, tiered project-driven learning, and process-oriented evaluation—contributes to enhancing students' engineering practice competence, innovation capability, and professional adaptability. It provides meaningful implications for advancing educational reform in Electronic Information Engineering within applied universities, deepening industry–education integration, and cultivating high-quality engineering talent aligned with the needs of intelligent manufacturing and the new energy vehicle industry.

References

- [1] Ministry of Education, Ministry of Industry and Information Technology, & Chinese Academy of Engineering. (2018). *Opinions on accelerating the development of emerging engineering education and implementing the excellence engineer education and training program 2.0* (Jiaogao No. 3). https://hudong.moe.gov.cn/srcsite/A08/moe_742/s3860/201810/t20181017_351890.html
- [2] General Office of the State Council of the People's Republic of China. (2017). *Several opinions on deepening the integration of industry and education* (Guobanfa No. 95). https://www.beijing.gov.cn/zhengce/gwywj/201905/t20190522_60736.html
- [3] Lin, J. (2017). Construction of China's emerging engineering education oriented to the future. *Research in Education of Tsinghua University*, 38(2), 26–35.
- [4] Zhong, D. (2017). Connotation and action of emerging engineering education construction. *Research in Higher Engineering Education*, (3), 1–6.
- [5] Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university* (4th ed.). Open University Press.
- [6] Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, 95(2), 123–138.
- [7] Graham, R. (2018). *The global state of the art in engineering education*. Massachusetts Institute of Technology.
- [8] Wu, A., Hou, Y., & Yang, Q. (2020). Emerging engineering education driven by industry–education integration: Core concepts and practical exploration. *Research in Higher Engineering Education*, (4), 7–15.
- [9] Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3–4), 369–398. <https://doi.org/10.1080/00461520.1991.9653139>
- [10] Yu, L., & Peng, B. (2024). Innovative practice of teaching-guided project design and evaluation methods in local engineering universities. *Research in Higher Engineering Education*, (2), 91–96.
- [11] Zhang, Y., Ma, X., Liu, H., & Huang, Y. (2026). Innovative practice and effectiveness verification of the OBE-oriented PAD–PBL integrated model in the teaching of "Quality Management". *Standard Science*, (2), 69–77.