

Analysis of problems and practical strategies in new energy vehicle fault diagnosis courses at application - oriented universities

Weipeng Sun¹, Lin Xi^{1}, Weijia Xu¹, Bo Tan¹*

¹Geely University of China, Chengdu, China

*Corresponding Author. Email: 1923878906@qq.com

Abstract. Presently, applied universities commonly encounter prominent challenges in the development of new energy vehicle fault diagnosis courses. These challenges encompass obsolete course content, inadequate practical teaching resources, ineffective school - enterprise collaborative education mechanisms, and the lack of a professional certification system. To tackle these issues, this paper puts forward a model characterized by "moderately forward - looking planning, phased procurement, integration of virtual and real resources, and university - industry collaboration" to alleviate the shortage of practical teaching resources. It advocates leveraging in - depth industry - education integration to drive the synchronized updates of teaching content and technology, establishing an integrated course - certification system to streamline university - industry certification channels, and implementing a "progressive" course system. A three - step implementation path for course reform is adopted to improve the quality of course teaching and cultivate new energy vehicle diagnostic and maintenance talents with practical skills and enhanced market competitiveness.

Keywords: applied universities, new energy vehicle fault diagnosis courses, talent cultivation

1. Introduction

With the deepening of the global energy transition, China's new energy vehicle industry has entered a stage of explosive growth. According to the projections in the Manufacturing Talent Development Plan Guide jointly issued by three ministries, including the Ministry of Industry and Information Technology, by 2025, China will encounter a shortage of 1.03 million professionals in the new energy vehicle field, among which the aftermarket alone accounts for 80% of this shortfall. This significant shortage of specialized maintenance personnel for new energy vehicles not only offers employment opportunities propelled by the industry's rapid development but also poses substantial challenges for applied universities in terms of talent cultivation and curriculum design for new energy vehicle programs.

2. Analysis of the educational objectives of new - energy vehicle fault diagnosis courses

The Notice on Conducting Research and Practice in New Engineering Disciplines issued by the Ministry of Education has delineated a path for universities to nurture all - around talents who possess both engineering practical skills and the capacity to address complex engineering problems in new contexts. As the primary driving force in fulfilling regional industrial requirements and cultivating applied talents with a solid technical foundation and strong practical abilities, applied undergraduate institutions are obliged to assume an increasingly significant role.

2.1. Talent development positioning of new energy vehicle programs in applied universities

Actively serving the high-quality development of regional economies and cultivating urgently needed technical talent defines the role of applied universities within China's higher education system. This clear institutional positioning must be explicitly reflected in the development of new energy vehicle programs [1]. To align with national strategic demands, serve local economic development, and advance technological upgrades in the new energy vehicle industry, applied universities' new energy vehicle programs should cultivate high-caliber applied professionals. These graduates must possess the technical proficiency to solve critical systemic engineering problems in new energy vehicles, strong engineering practice capabilities, innovative spirit, and the ability to engage in new energy vehicle-related positions. Guided by this institutional positioning and professional talent

development objectives, the new energy vehicle fault diagnosis course plays a vital role in tightly integrating professional theoretical knowledge with engineering practice capabilities [2].

2.2. Course objectives for new energy vehicle fault diagnosis

Currently, numerous domestic scholars have conducted targeted research on the new energy vehicle industry from perspectives including its sector characteristics, competency requirements, and regional distribution disparities. Meng Zhixiang [3] and others point out that the current domestic market faces a significant shortage of new energy vehicle maintenance personnel with varying skill levels. The industry ultimately demands "high-level, high-quality, and highly skilled" triple-competency professionals. Wu Lei [4] and Zhou Xiu [5] both highlight that current training for new energy vehicle maintenance personnel suffers from a disconnect between teaching content and industry needs, necessitating deeper alignment between vocational education and industrial demands. Additionally, Huang Zhi et al. [6] proposed an integrated education model combining "job, course, competition, and certification." They emphasized that leveraging school-enterprise resources, optimizing curriculum content, and incorporating ideological and political elements can significantly enhance students' practical capabilities. Liu Shan [7] and Jiang Xingyang [8] respectively supplemented curriculum reform pathways from the perspectives of ideological and political development and assessment evaluation. Consequently, existing research confirms that teaching effectiveness can be enhanced through measures such as optimizing curriculum development and innovating teaching methods, providing theoretical support for formulating the teaching objectives of this course.

The "New Energy Vehicle Fault Diagnosis" course is a core professional course for the New Energy Vehicle Engineering program. Through this course, students will master the fundamental knowledge, principles, and methods of high-voltage safety operations for new energy vehicles, fault diagnosis techniques for new energy vehicles, the structural principles and fault diagnosis of hybrid electric vehicles, and the diagnosis and troubleshooting of pure electric vehicles. The course guides students to thoroughly study various systems, develop logical thinking patterns for constructing analyses and solving problems, and acquire the ability to address complex real-world engineering challenges. It cultivates independent thinking and a pragmatic scientific spirit, laying a solid theoretical foundation and providing rich practical experience for careers in new energy vehicle maintenance, inspection, and fault repair.

3. Pedagogical challenges in new energy vehicle fault diagnosis courses at applied universities

This research centers on third- and fourth-year students majoring in new energy vehicles at three applied universities in western China. These students have completed the "New Energy Vehicle Fault Diagnosis" course and have direct insights into its development, which allows them to accurately identify the existing teaching problems and the areas that urgently need improvement. A total of 206 questionnaires were distributed, and 168 were retrieved, with a response rate of 81.6%. The feedback indicated high feasibility. The key findings and statistical results of the survey are presented in Table 1.

Table 1. Statistical results of core survey content

Primary Research Content	Key Statistical Findings	Summary of Core Questions
Whether training equipment is sufficient	Completely inadequate (15.0%); Partially inadequate (41.6%); Generally adequate (36.3%)	Equipment conditions do not fully meet teaching requirements
Most Critical Diagnostic Skills (Multiple Choices)	Power battery fault diagnosis (86.73%); High-voltage safety inspection (84.07%); Motor controller analysis (46.9%)	Course content should prioritize diagnostic skills for new energy vehicle three-electric systems
Weakest areas mastered in the course	Data stream analysis and waveform reading (24.8%); Use of new diagnostic equipment (23.9%); Standardization of fault diagnosis procedures (23.9%)	Students exhibit significant deficiencies in complex data analysis and equipment operation capabilities
Desired proportion of practical training in courses	Practical instruction should constitute 50% (36.28%); 60% (21.24%); 80% (24.78%); other proportions (17.7%)	Practical teaching proportion should be increased to approximately 60%
Exposure to real-world business cases	0-20% (22.12%); 20-40% (37.17%); 40-60% (29.2%); 60-80% (7.08%); 80-100% (4.42%)	Lack of authentic case resources; teaching content disconnected from real-world work scenarios
Alignment of course content with industry developments	Basically in sync (37.2%); lagging behind the industry by 1-2 years (41.6%)	Curriculum content updates lag behind and need to keep pace with industrial technological advancements
Preferred teaching methods	Hands-on vehicle disassembly/assembly training (37.2%); Corporate engineers teaching on campus (25.7%); Simulation training platforms (21.2%)	Teaching methods should be diversified and integrated, emphasizing practical skills and industry alignment
Desired certifications (multiple selections)	High-voltage electrician certification (57.5%); New Energy Vehicle 1+X vocational skills certificate (52.2%); OEM certification from automotive manufacturers (47.79%)	Students have clear certification needs; strengthen alignment with industry qualifications
Gaps between graduates and corporate needs (multiple selections)	Proficiency in equipment operation (75.2%); Complex problem-solving ability (63.7%); Pace of technological updates (55.8%)	Disconnect between schools and enterprises leads to mismatch between graduate skills and job requirements

3.1. Insufficient training equipment and lack of practical experience

As a vital vehicle for cultivating applied technical skills, specialized training equipment serves as the foundational tool for students to master core competencies. Survey findings reveal a significant gap between the shortage of training equipment and students' desire to increase practical training hours to enhance hands-on experience. The primary reasons are twofold: first, the rapid technological iteration in new energy vehicle technology has rendered training equipment functionally obsolete, failing to meet market demands; second, when such equipment experiences malfunctions or aging, there is no dedicated personnel for maintenance and repairs. Consequently, while the quantity of equipment may appear sufficient, the number of functional units is actually limited. Clearly, the rationality and foresight in allocating practical teaching resources have become key indicators for evaluating the quality of this curriculum.

3.2. Insufficient coverage of key technologies and weak data analysis capabilities

Statistical data from Table 1 reveals significant structural deficiencies in new energy vehicle fault diagnosis courses at surveyed institutions. Power battery fault diagnosis was identified by 86.73% of respondents as the most critical skill requiring enhancement, closely followed by high-voltage system safety inspection at 84.07%. This underscores the need to increase practical training proportions in areas like power batteries and high-voltage systems to meet real-world workplace demands. Simultaneously, the course content itself exhibits weaknesses, revealing insufficient systematic training in fundamental analysis and standardized process development. Finally, gaps exist in data application capabilities. As a critical competency, data flow analysis suffers not only from low training coverage but also from a lack of sufficient real-world case studies, resulting in a disconnect between course theory and practical application.

3.3. Curriculum lags behind industry technology, content lacks corporate case studies

The current pace of curriculum updates lags significantly behind the industry's rapid development, highlighting the urgent need to align teaching with practical job requirements. Overall data indicates that over half of respondents believe course content fails to keep pace with industry advancements, resulting in graduates who are ill-equipped for job demands. 65.49% of respondents expressed a desire to increase the number of real-world enterprise work orders in course content optimization, while 54.87% favored industry experts participating in teaching. These preferences reflect students' desire to integrate high-quality industry resources into teaching materials and their strong willingness to pursue careers in their field after graduation.

3.4. Curriculum disconnect from certifications hinders professional qualification acquisition

Professional certifications serve as a critical bridge connecting students' skill acquisition to job market entry, directly impacting their employ-ability and career progression. However, significant room for improvement remains in aligning teaching resources with certification support. Regarding certification support, 57.52% of respondents expressed interest in obtaining the "High-Voltage Electrician Operation Certificate," while 52.21% sought the "1+X Certificate." Notably, some respondents expressed interest in acquiring both certifications. There is a noticeable disconnect between certification content and classroom instruction. The knowledge points covered in theoretical teaching do not align well with actual certification exam topics, making it difficult for students to pass exams directly or acquire the qualifications required for specific positions. This necessitates additional pre-test training after completing coursework, increasing both the learning burden and time costs.

4. System construction of new energy vehicle fault diagnosis courses in applied universities

4.1. Multi-pronged approach to enhancing practical teaching resources

To address the current shortages in equipment and practical teaching resources, feasible improvement measures can be implemented across four dimensions: "moderately forward-looking planning, phased procurement, integration of virtual and physical resources, and university-industry collaboration."

1) Moderately forward-looking planning should involve inviting industry experts with strategic vision to conduct forward-looking assessments of practical teaching needs for the next 3 to 5 years, based on industry technology trends and job competency requirements.

2) Equipment procurement should be executed in phases. This prioritizes core, high-frequency-use equipment to ensure coverage of critical teaching content and practical tasks, allowing subsequent adjustments to the procurement list based on actual needs.

3) For high-value, high-usage equipment like autonomous driving sensor calibration tools, virtual simulation technology can serve as an alternative. This enables blended online-offline learning, reducing reliance on physical devices.

4) For specialized equipment with stronger research capabilities and higher value, consider establishing joint laboratories with enterprises or research institutions. This model involves the university providing space while the partner contributes technical support and shares equipment costs. This approach alleviates financial pressure and maximizes utilization of high-value, low-usage equipment.

4.2. Deepening industry-education integration to drive synchronized updates in teaching content and technology

To address the issue of curriculum lagging behind industry development, improvements can be made through deep industry-education integration and establishing a curriculum feedback mechanism, enhancing the leading role and practicality of teaching content. From the perspective of deepening industry-education integration, establish a long-term mechanism for collaborative talent cultivation between universities and enterprises to synchronize curriculum updates with industrial advancements [9,10]. First, invite enterprise technical experts to fully participate in revising course outlines, optimizing teaching content, and developing supporting textbooks. Second, create "corporate mentor" or "industry professor" positions to provide insights for cultivating application-oriented talents that meet corporate needs. Third, during course implementation, regularly organize collective lesson planning sessions and conduct unscheduled assessments of teaching quality by enterprises. The school provides feedback on optimization suggestions to achieve resonance between teaching content and industry development, thereby effectively transforming course content from static and closed to dynamically updated.

4.3. Refining the teaching system to strengthen core technical competency development

To address issues such as outdated course content and gaps in core competency development, specific improvement measures can be implemented in areas like curriculum structure optimization, practical skill enhancement, and data literacy cultivation.

1) Enhance the proportion of practical training hours for core skills that are indispensable for industry professionals. Outfit classrooms with standard operational equipment and adopt corporate standard operating procedures as operational guidelines. This guarantees that students undergo systematic training in key technologies on campus.

2) Broaden the curriculum scope to encompass emerging technologies such as battery health prediction and OTA upgrades. Complement teaching with virtual simulation software to overcome equipment limitations, gradually augmenting the course's scope and technical profundity in intelligent systems.

3) To improve students' logical thinking and independent problem - solving capabilities, specialized training in standardized fault - handling procedures should be incorporated into teaching. This process should be guided through mentorship rather than direct instruction, motivating students to comprehensively analyze fault phenomena, master diagnostic steps, and reinforce logical reasoning skills. Simultaneously, increase training in data interpretation during diagnostics to enhance students' ability to address complex issues.

4.4. Reconstructing teaching and assessment systems to strengthen job-specific competency development

To address current issues of suboptimal teaching outcomes and insufficient practical skills among students, instructional innovation should leverage online resources combined with flipped classroom models. Theoretical knowledge should be delivered pre-class through platforms like MOOCs, XuetangX, or course-specific online resources, guiding students to master foundational concepts beforehand. Classroom time should then focus on addressing questions from prior theoretical learning, with the remainder dedicated entirely to hands-on training. Instructors provide on-site guidance as students complete tasks, boosting classroom efficiency while reinforcing skill mastery.

4.5. Establish an integrated curriculum-certification system to facilitate industry-academic certification channels

Professional certifications serve as crucial entry qualifications for students entering industries. Holding relevant professional qualification or grade certificates significantly boosts students' employment competitiveness. Establishing a "course-certification integration" mechanism enables efficient alignment between teaching content and certification exam topics. Course content closely follows the syllabus of professional grade certification exams, making it more targeted and purposeful while avoiding disconnects.

Specifically for this course development: First, establish a mapping of exam content, systematically embedding key topics into course modules and integrating corresponding practice question banks. This ensures students acquire foundational certification knowledge while completing coursework. Second, increase the proportion of dual-qualified instructors by requiring all teaching faculty to first obtain relevant professional certifications. Third, promote industry-academia joint certification mechanisms. For instance, Geely University leverages its corporate affiliation to establish manufacturer-certified pathways with Geely Group's automotive brands (Geely Galaxy, Lynk & Co, Volvo, etc.). During assessment periods, companies send examiners to campus to jointly conduct certification exams. This explores a model where "passing course assessments qualifies students for original manufacturer certification exams," providing a more direct and efficient certification pathway that aligns with both student development expectations and corporate hiring trends.

5. Practical pathways for new energy vehicle fault diagnosis courses in applied universities

To expedite the development of a cultivation system for new energy vehicle technical talents, efforts should be advanced in a phased and step - by - step manner.

In the short - term plan, within one year, priority should be given to the acquisition of foundational course equipment and the establishment of core content. This involves procuring core teaching equipment such as battery management systems and vehicle control systems, and developing 5 to 10 practical training project modules based on real enterprise work orders to ensure that the course content is closely aligned with actual job requirements. Simultaneously, a collaborative curriculum development mechanism with enterprises should be established. Corporate engineers should be regularly invited to deliver lectures or specialized seminars on campus to enhance the practicality and relevance of teaching. Leveraging the "industry - education integration" mechanism, pilot "course - certification integration" classes should be launched at appropriate times. The 1 + X certificate examination system should be incorporated into the curriculum framework to lay a foundation for students' future professional certification.

For the mid-term planning, over a 2-3-year cycle, efforts will be concentrated on expanding and refining teaching resources. A virtual simulation training center will be established, utilizing VR and AR technologies to cover over 80% of high-cost equipment operation segments, thereby reducing training costs and broadening the instructional scope. Building on the existing industry-education integration, the aim is to secure direct certification agreements with 3-5 leading automakers (e.g., Geely, BYD) to establish a seamless pathway from learning to certification for students. School-based textbooks and supporting technical manuals with dynamic updates should be developed and released to ensure that the teaching content keeps abreast of industry advancements.

In pursuit of long-term goals, a comprehensive "teaching-practice-certification-employment" closed-loop education system ought to be established within a period of 3 to 5 years, thereby strengthening institutional frameworks and consolidating achievements. Through the systematic implementation and phased progression of these measures, curriculum development will be more effectively aligned with industry trends, and students' professional competencies for employment will be comprehensively improved.

6. Conclusion

In general, this study pinpoints deficiencies in the teaching content, practical models, assessment systems, and certification alignment of new-energy vehicle fault diagnosis courses in applied universities, and puts forward targeted systematic reform approaches. Nevertheless, considering the high dynamism and technological complexity of industrial development, future endeavors should intensify the exploration of integrating emerging technologies such as intelligent driving into teaching. Moreover, more representative empirical research on the effectiveness of virtual simulation and remote training in new-energy vehicle diagnostics education is required.

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