

Construction of an Industry Demand-Oriented Teaching Quality Evaluation System for Vocational Undergraduate Education: A Case Study of the Intelligent Connected New Energy Vehicle Professional Cluster

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Abstract:

The Intelligent Connected New Energy Vehicle (ICNEV) industry demands high-level technical professionals with interdisciplinary competencies, placing new requirements on vocational undergraduate education. This study proposes an industry demand-oriented teaching quality evaluation system using the ICNEV Professional Cluster as a case study. Guided by Outcome-Based Education (OBE), competency-based education, and industry-education integration, a three-level evaluation index system was constructed through literature analysis, industrial competency mapping, Delphi expert consultation, and the Analytic Hierarchy Process (AHP). The framework establishes systematic linkages among industrial demand, occupational competencies, talent cultivation objectives, curriculum systems, teaching implementation, practical training, and learning outcomes, forming a closed-loop continuous improvement mechanism. The proposed system introduces industrial competency requirements as the starting point of evaluation, constructs a multidimensional framework for interdisciplinary professional clusters, and establishes a multi-stakeholder quality assurance mechanism. The findings offer practical references for quality assurance in vocational undergraduate institutions serving emerging strategic industries.

Keywords:

Vocational Undergraduate Education, Teaching Quality Evaluation, Outcome-Based Education, Industry-education Integration, Intelligent Connected New Energy Vehicles, Professional Cluster, Competency-based Education, Analytic Hierarchy Process

1. Introduction

The transformation of the global automotive industry, driven by electrification, digitalization, intelligent connectivity, and artificial intelligence, has fundamentally reshaped workforce requirements. Intelligent Connected New Energy Vehicles

(ICNEVs) integrate advanced technologies such as autonomous driving, vehicle-road-cloud collaboration, battery management, intelligent manufacturing, and big data, generating increasing demand for professionals possessing interdisciplinary competencies, engineering practice capability, and innovation awareness [1,2].

Vocational undergraduate education has assumed an increasingly significant role in cultivating application-oriented professionals capable of supporting industrial transformation. Compared with traditional higher vocational education, vocational undergraduate programs emphasize advanced technical competencies, complex engineering problem-solving, technological innovation, and sustainable career development [3]. Consequently, teaching quality has become a key determinant of whether these institutions can effectively respond to industrial upgrading [4].

In recent years, Outcome-Based Education (OBE), competency-based education, and industry-education integration have been widely promoted to strengthen the alignment between educational outcomes and labor market demand [5,6]. Curriculum systems, practical training, engineering projects, and enterprise participation are expected to reflect evolving occupational competency requirements rather than merely satisfying institutional objectives [7].

Existing research has provided valuable foundations for teaching quality evaluation. Recent studies have proposed multidimensional frameworks incorporating curriculum design, instructional implementation, faculty development, practical training, learning outcomes, and institutional governance [8,9]. Research on OBE and engineering accreditation has highlighted the importance of learning outcomes, continuous improvement, and stakeholder participation [5,10]. Furthermore, industry-education collaboration has been recognized as an effective mechanism for enhancing graduate employability [7,11].

Nevertheless, several issues remain underexplored. First, while industry participation has been incorporated into evaluation, existing frameworks often remain organized from institutional perspectives; the systematic translation of dynamic industrial competency requirements into measurable teaching quality indicators warrants further strengthening [9,12]. Second, evaluation studies predominantly focus on individual programs, whereas professional clusters characterized by interdisciplinary integration and close industrial value chain connections have received less attention. Third, mechanisms for dynamically responding to technological evolution and occupational competency changes remain relatively underexplored [4].

The ICNEV Professional Cluster provides an appropriate context for addressing these issues. Unlike conventional disciplinary structures, this professional cluster integrates automotive engineering technology, intelligent vehicle engineering, electronic information technology, intelligent manufacturing, and software engineering around the complete industrial chain. Such interdisciplinary characteristics require teaching quality evaluation to comprehensively consider curriculum integration, engineering practice, enterprise participation, innovation capability, and graduate competency development [1,2].

Accordingly, this study aims to construct an industry demand-oriented teaching quality evaluation system for vocational undergraduate education. Guided by OBE, competency-based education, and industry-education integration, a three-level evaluation index system is developed through literature analysis, industrial

competency mapping, Delphi expert consultation, and AHP. The study contributes to existing research by: (1) introducing industrial competency requirements as the starting point for constructing evaluation indicators [5]; (2) developing a multidimensional framework for interdisciplinary professional clusters [13]; and (3) establishing a multi-stakeholder evaluation mechanism supporting evidence-based continuous quality improvement [10].

The remainder of this paper is organized as follows. Section 2 reviews relevant literature on teaching quality evaluation, OBE, industry-education integration, and ICNEV industry demand. Section 3 presents the research methodology. Section 4 describes the construction of the evaluation system. Section 5 discusses theoretical and practical implications. Section 6 concludes with major findings, limitations, and future directions.

2. Literature Review

2.1. Teaching Quality Evaluation in Vocational Undergraduate Education

Teaching quality evaluation is a core component of educational quality assurance, with recent global trends emphasizing data-driven, competency-oriented, and industry-aligned approaches [8]. As vocational higher education has shifted from scale expansion to quality-oriented development, evaluation systems have evolved toward multidimensional frameworks integrating educational objectives, curriculum implementation, learning outcomes, and stakeholder participation [9]. In engineering and vocational education, evaluation is increasingly expected to measure both teaching effectiveness and graduates' professional competency attainment, reflecting the growing emphasis on alignment between educational processes and labor market requirements [11].

Studies in the Chinese context have highlighted the importance of constructing systematic evaluation frameworks that reflect the unique positioning of vocational undergraduate education. A recent systematic review of vocational education reform in China identified curriculum design, instructional delivery, practical teaching, faculty development, graduate employability, and institutional governance as essential dimensions [12]. Furthermore, quality assurance systems have introduced evidence-based mechanisms integrating internal quality monitoring with external stakeholder feedback [10].

For vocational undergraduate education specifically, evaluation frameworks must reflect both higher education standards and occupational requirements. Existing studies suggest that the emphasis on curriculum design, practical teaching, industry participation, and graduate outcomes varies considerably across disciplines [9]. These differences indicate that evaluation should be appropriately adapted to the characteristics of emerging industrial sectors and interdisciplinary professional clusters.

2.2. Outcome-Based Education and Industry–Education Integration

Outcome-Based Education has become one of the most influential paradigms guiding engineering and vocational education reform. A recent systematic review confirms that OBE emphasizes student-centered learning, measurable competency attainment, constructive alignment, and continuous improvement, with particular relevance to engineering and technology programs, and growing alignment with

sustainable development goals [5]. Educational objectives, curriculum systems, teaching activities, and assessment methods are designed through backward planning, ensuring graduates acquire knowledge, skills, and competencies required by society and industry.

The implementation of OBE has significantly influenced vocational undergraduate education. Studies demonstrate that integrating OBE with project-based learning and engineering education accreditation standards strengthens students' engineering practice, interdisciplinary collaboration, and innovation competence [10]. More importantly, OBE encourages institutions to establish systematic feedback mechanisms in which curriculum revision and teaching improvement are continuously informed by learning outcomes and stakeholder evaluation [5, 6].

Parallel to OBE, industry–education integration has become a strategic priority in vocational education reform globally [11]. Recent research advocates deep collaboration throughout the entire talent cultivation process, including joint curriculum development, enterprise teaching participation, dual-qualified faculty development, collaborative research, shared training facilities, and co-construction of professional standards [7]. Empirical studies indicate that combining OBE with industry–education integration creates a more responsive educational ecosystem, enabling institutions to translate enterprise competency requirements into curriculum objectives and assessment criteria, though the relationship requires careful institutional design [7,11].

2.3. Industry Demand Analysis for ICNEV

The ICNEV industry has emerged as one of the most dynamic strategic industries worldwide, with global electric vehicle sales surpassing 17 million units in 2024 [1]. Driven by electrification, intelligent driving, vehicle networking, and digital manufacturing, the automotive industry is rapidly evolving from traditional manufacturing toward intelligent mobility ecosystems [2]. This transformation has fundamentally reshaped occupational structures and competency requirements.

Industrial reports consistently indicate that enterprises increasingly value interdisciplinary competencies extending beyond conventional automotive engineering. Graduates are expected to demonstrate capabilities in intelligent control systems, embedded software development, battery management, vehicle communication technologies, autonomous driving algorithms, industrial data analysis, and intelligent manufacturing [1,2]. Beyond technical expertise, employers emphasize transferable competencies including systems thinking, engineering ethics, teamwork, project management, innovation capability, and lifelong learning [6].

The professional cluster concept provides an effective organizational framework for cultivating interdisciplinary professionals. The ICNEV Professional Cluster integrates automotive engineering technology, intelligent vehicle engineering, electronic information technology, intelligent manufacturing, software engineering, and digital maintenance [2]. Such integration requires close coordination among curriculum systems, practical teaching platforms, faculty teams, and enterprise resources. Accordingly, teaching quality evaluation should comprehensively assess interdisciplinary collaboration, curriculum integration, engineering practice, and industry participation.

2.4. Research Gap and Theoretical Foundation

The literature demonstrates considerable progress in teaching quality evaluation, OBE, competency-based education, and industry–education integration. However, several gaps remain. First, although industry participation is widely acknowledged, the systematic translation of dynamic industrial competency requirements into measurable teaching quality indicators has not been fully systematized [9,12]. Second, previous studies have mainly focused on individual disciplines or specific courses, with less attention devoted to professional clusters characterized by interdisciplinary integration and complex engineering practice. Third, while stakeholder participation is advocated, practical mechanisms for incorporating multi-source evaluation evidence remain diverse across institutions [8]. Fourth, many evaluation frameworks are relatively static, whereas rapidly evolving industries such as ICNEV require dynamic adjustment mechanisms responsive to changing technologies and competency requirements [1].

Drawing upon these observations, this study adopts OBE, competency-based education, and industry-education integration as its theoretical foundation. Rather than treating industrial demand as an external reference, the study positions industrial competency requirements as the starting point for constructing the evaluation framework. Through the logical progression from industrial demand to occupational competencies, talent cultivation objectives, curriculum systems, teaching implementation, practical training, learning outcomes, and continuous improvement, a three-level evaluation index system is developed to support evidence-based quality assurance in vocational undergraduate professional clusters [5,6,7].

3. Research Methodology

3.1. Research Design

This study adopts a mixed-method research design to develop an industry demand-oriented teaching quality evaluation system. The qualitative component focuses on identifying ICNEV industry competency requirements through literature analysis, industrial competency analysis, and expert consultation, thereby establishing the conceptual framework and evaluation indicators. The quantitative component employs the Analytic Hierarchy Process (AHP) to determine indicator weights and improve the evaluation system's objectivity [13].

The research design follows the principle of “industry demand drives educational quality evaluation”. Rather than constructing indicators solely from educational management perspectives, the framework begins with industrial competency requirements and progressively establishes relationships among occupational competencies, talent cultivation objectives, curriculum systems, teaching implementation, practical training, and learning outcomes. This approach is consistent with OBE and competency-based education [5,6].

3.2. Research Framework

The research framework consists of four interconnected stages.

Stage 1: Industrial Demand Analysis: ICNEV competency requirements are analyzed through literature review, policy analysis, industrial standards [3], and occupational competency frameworks to identify knowledge, technical skills, engineering capabilities, and professional qualities expected by employers [1,2].

Stage 2: Preliminary Indicator Construction: Industrial competency requirements are translated into educational evaluation indicators following competency-based education logic, establishing a preliminary three-level indicator system [6].

Stage 3: Indicator Optimization and Weight Determination: The Delphi method is employed to refine indicators through iterative expert consultation. After achieving consensus, AHP determines the relative importance of each indicator through pairwise comparison and consistency testing [13,14].

Stage 4: Evaluation Framework Construction: Optimized indicators and weights are integrated into a comprehensive evaluation framework supporting educational diagnosis, quality monitoring, and continuous improvement.

3.3. Research Procedure

3.3.1. Literature Analysis

A systematic review was conducted covering teaching quality evaluation, OBE, competency-based education, industry–education integration, engineering education accreditation, and vocational undergraduate education [5,8,9,10,12,13].

3.3.2. Industrial Competency Analysis

ICNEV industry competency requirements were analyzed with particular attention to emerging occupational requirements related to intelligent manufacturing, autonomous driving systems, battery management, Internet of Vehicles, intelligent diagnostics, and engineering integration [1,2].

3.3.3. Preliminary Indicator Construction

Based on the literature review and competency analysis, a preliminary three-level evaluation indicator system was established, organizing indicators according to the logical progression from industrial demand through educational implementation to learning outcomes.

3.3.4. Delphi Expert Consultation

The Delphi method was adopted to improve the scientific validity and practical applicability of the indicator system. Experts were selected from vocational undergraduate institutions, industrial enterprises, professional associations, and educational research organizations. The consultation focused on four aspects: scientific validity, relevance to industrial competency requirements, clarity of indicator definitions, and operational feasibility. The indicator system was revised iteratively according to expert opinions until stable consensus was achieved [13,14].

3.3.5. Analytic Hierarchy Process

AHP was employed to determine indicator weights. Through pairwise comparison using Saaty's nine-point scale, qualitative expert judgments are transformed into quantitative weights with consistency verification. Recent applications have demonstrated AHP's effectiveness in vocational education evaluation contexts, particularly when combined with the Delphi method [13,14].

3.4. Methodological Rationale

The methodological combination reflects complementary advantages. Literature analysis provides the theoretical basis by identifying internationally recognized quality assurance concepts [8,9]. Industrial competency analysis ensures practical

relevance by responding to actual technological development and occupational requirements [1,2]. The Delphi method facilitates consensus building among experts from diverse backgrounds while reducing the influence of dominant individual opinions [13]. AHP provides a structured quantitative approach for determining indicator weights with improved transparency and interpretability [14]. Together, these methods establish a rigorous research process in which theoretical analysis, industrial demand, expert knowledge, and quantitative decision-making jointly contribute to the evaluation system.

3.5. The Delphi–AHP Evaluation Model

The Delphi method first optimizes the preliminary indicator system through iterative expert consultation, refining redundant indicators, clarifying ambiguous descriptions, and improving the overall logical structure. Subsequently, AHP is used to establish pairwise comparison matrices for indicators at different hierarchical levels. Experts compare the relative importance of indicators according to Saaty's scale, allowing indicator priorities to be calculated through eigenvector analysis with consistency testing [13,14].

The resulting integrated evaluation model provides a structured mechanism for diagnosing educational quality and supporting evidence-based decision-making. Rather than serving solely as an assessment instrument, the model functions as a continuous quality assurance mechanism, forming a closed-loop process of “evaluation–feedback–improvement–re-evaluation” that supports sustainable enhancement of teaching quality [5,10].

4. Construction of the Industry Demand-Oriented Teaching Quality Evaluation System

4.1. Design Principles

The evaluation system design was guided by four principles. (1) Industry Demand Orientation: all indicators are derived from industrial development trends, occupational competency standards, and enterprise expectations [6,7]. (2) Outcome Orientation: guided by OBE, the framework focuses on graduates' competency attainment through learning outcomes, engineering practice, innovation, and professional adaptability [5]. (3) Systematic Integration: considering the interdisciplinary characteristics of professional clusters, the system integrates curriculum construction, teaching implementation, practical education, faculty development, industry participation, and learning outcomes. (4) Continuous Improvement: the framework establishes a feedback loop in which evaluation results support curriculum revision, resource allocation, and professional cluster optimization [10].

4.2. Overall Framework

Unlike traditional models beginning with institutional objectives, the proposed framework follows the logical pathway: Industrial Development → Industrial Competency Requirements → Occupational Competency Standards → Talent Cultivation Objectives → Teaching Quality Evaluation → Continuous Quality Improvement. Industrial competency requirements serve as the driving force, and occupational competency standards are transformed into educational objectives and curriculum requirements. Teaching implementation and practical education are

evaluated against these objectives, while learning outcomes provide evidence for continuous improvement [5,6].

4.3. Three-Level Evaluation Indicator System

Based on literature analysis, industrial competency mapping, and Delphi consultation, a hierarchical evaluation system was established comprising six Level I indicators (evaluation dimensions), twenty-four Level II indicators (evaluation categories), and seventy-two Level III indicators (observable evaluation items). This structure provides comprehensive representation of teaching quality in vocational undergraduate education.

4.3.1. Level I Evaluation Dimensions

The six Level I indicators are: (A1) Teaching Objectives — evaluating whether program objectives reflect industrial development, occupational standards, and vocational undergraduate positioning; (A2) Curriculum System — examining curriculum structure, integration, interdisciplinary design, and content updating mechanisms; (A3) Teaching Implementation — evaluating instructional organization, digital teaching, project-based learning, and competency-oriented assessment; (A4) Practical Teaching — focusing on engineering practice, enterprise internships, practical projects, and intelligent training platforms; (A5) Industry–Education Collaboration — measuring the depth and effectiveness of school–enterprise cooperation; and (A6) Learning Outcomes — evaluating graduates’ professional competence, engineering capability, innovation ability, employment quality, and lifelong learning capacity.

4.3.2. Hierarchical Structure of the Indicator System

Each Level I indicator is further decomposed into four Level II indicators, with every Level II indicator containing three measurable Level III indicators. The complete evaluation system is presented in Table 1.

Table 1. Three-Level Teaching Quality Evaluation Indicator System.

Level I Indicator	Level II Indicator	Representative Level III Indicators
A1 Teaching Objectives	Objective Alignment	Industrial strategy alignment; Occupational standards; OBE outcomes
	Competency Objectives	Engineering competence; Innovation capability; Sustainable development
	Programme Positioning	Interdisciplinary integration; Professional cluster coordination; Regional adaptability
	Continuous Optimisation	Enterprise participation; Graduate feedback; Periodic revision
A2 Curriculum System	Curriculum Structure	General education; Professional foundation; Specialised modules
	Curriculum Content	Intelligent technologies; Digital integration; Green development
	Curriculum Integration	Modular curriculum; Interdisciplinary courses; Project integration
	Curriculum Updating	Enterprise participation; Industrial standards; Dynamic revision
A3 Teaching Implementation	Teaching Methods	Project-based learning; Case-based learning; Problem-based learning
	Digital Teaching	Smart classrooms; Digital resources; Virtual simulation
	Teaching Management	Teaching supervision; Process management;

		Reflective improvement
	Assessment Reform	Process assessment; Competency assessment; Outcome evaluation
A4 Practical Teaching	Practical Curriculum	Experimental teaching; Engineering projects; Practice proportion
	Enterprise Practice	Workplace learning; Enterprise mentors; Internship quality
	Engineering Projects	Real industrial projects; Team collaboration; Innovation practice
	Practical Platforms	Intelligent laboratories; Training bases; Virtual simulation
A5 Industry–Education Collaboration	School–Enterprise Cooperation	Joint curriculum; Joint laboratories; Collaborative education
	Enterprise Participation	Enterprise experts; Technical guidance; Enterprise evaluation
	Resource Sharing	Equipment sharing; Industrial projects; Training resources
	Social Service	Technology transfer; Continuing education; Technical services
A6 Learning Outcomes	Professional Competence	Technical skills; Engineering practice; Problem solving
	Innovation Capability	Innovation projects; Competitions; Research participation
	Employment Quality	Employment relevance; Employer satisfaction; Career development
	Comprehensive Quality	Professional ethics; Teamwork; Lifelong learning

4.4. Industry Demand–Competency–Indicator Mapping

To strengthen connections between industrial development and educational evaluation, a competency mapping mechanism links industrial demand with evaluation indicators. The mapping follows the pathway: Industrial Development → Industrial Competency Demand → Occupational Competencies → Talent Cultivation Objectives → Curriculum System → Teaching Activities → Learning Outcomes → Teaching Quality Evaluation → Continuous Improvement. This mechanism demonstrates how changes in industrial competency requirements influence educational objectives and subsequently affect curriculum design, instructional implementation, and evaluation criteria, ensuring the evaluation system remains responsive to technological innovation [6,7].

4.5. Operational Mechanism

The evaluation system operates through a continuous quality assurance cycle involving five stages: (1) Data Collection — evidence gathered from teachers, students, enterprises, graduates, and administrators; (2) Comprehensive Evaluation — indicator scores calculated according to the AHP weighting system [13]; (3) Diagnostic Analysis — strengths and weaknesses identified in curriculum, practical teaching, industry collaboration, and learning outcomes; (4) Quality Improvement — strategies implemented through curriculum revision, teaching reform, and resource optimization; and (5) Continuous Monitoring — periodic evaluation establishing a closed-loop quality assurance mechanism [10].

4.6. Distinctive Features

Compared with existing frameworks, the proposed system demonstrates several distinctive features. First, it adopts industry demand as the logical starting point, strengthening alignment between talent cultivation and industrial development [7]. Second, evaluation indicators comprehensively reflect the interdisciplinary characteristics of ICNEV professional clusters by integrating engineering education, digital technologies, and practical teaching. Third, the framework establishes a multi-stakeholder evaluation mechanism incorporating educational institutions, enterprises, industry experts, teachers, students, and graduates [11]. Finally, the system functions as a dynamic quality assurance framework with continuous feedback and periodic revision capabilities responsive to technological advancement and industrial transformation [5,10].

5. Discussion

5.1. Interpretation of Findings

The findings suggest that teaching quality evaluation in vocational undergraduate education should move beyond institution-centred assessment toward an industry-responsive quality assurance framework. Conventional evaluation systems have concentrated on teaching management, curriculum implementation, classroom performance, and student satisfaction. Although these dimensions remain important, they may not fully capture talent cultivation effectiveness in strategic emerging industries characterized by rapid technological evolution [8, 9]. International organizations have increasingly emphasized the need for robust quality assurance mechanisms in vocational education systems to ensure alignment with evolving labor market requirements [15].

The proposed framework addresses this by positioning industrial competency requirements as the starting point of indicator construction. Rather than treating enterprise participation as an auxiliary evaluation dimension, the framework establishes a logical pathway linking industrial demand, occupational competencies, talent cultivation objectives, curriculum systems, teaching implementation, practical education, and learning outcomes. This approach reflects the competency-oriented philosophy advocated by OBE and strengthens consistency between educational objectives and industrial expectations [5,6].

Another important finding concerns interdisciplinary professional clusters. The ICNEV Professional Cluster integrates automotive engineering, intelligent manufacturing, electronic information, artificial intelligence, and software engineering. Consequently, teaching quality cannot be adequately evaluated through isolated course assessment alone. The proposed three-level evaluation system incorporates curriculum integration, engineering practice, interdisciplinary collaboration, and enterprise participation as essential quality components. Furthermore, the study demonstrates the importance of dynamic quality assurance, as industrial technologies and competency requirements continue evolving rapidly within intelligent manufacturing and mobility industries [1,2]. These trends underscore the broader significance of aligning educational quality with labor market opportunities, as demonstrated by research on engaging young people in vocational pathways through effective quality signaling [16]. Furthermore, cross-national analyses confirm that a nation's knowledge capital, measured by the quality of its education systems, is a fundamental driver of long-term economic prosperity [17].

5.2. Comparison with Previous Studies

Previous studies have established foundational contributions by emphasizing learning outcomes, competency development, educational effectiveness, and stakeholder participation [8,9]. Building upon these, the present research extends existing knowledge in several respects.

First, whereas many previous evaluation frameworks have primarily focused on institutional teaching quality, this study explicitly introduces industrial competency requirements as the logical origin of indicator construction, strengthening responsiveness to technological innovation and labor market transformation [12]. Second, while existing studies predominantly examine individual academic programs or specific teaching activities, the proposed framework is specifically designed for vocational undergraduate professional clusters characterized by interdisciplinary integration and collaborative talent cultivation. Third, the multi-stakeholder evaluation mechanism integrates educational institutions, enterprises, industry experts, teachers, students, and graduates into a unified quality assurance framework, strengthening both comprehensiveness and practical relevance in the context of emerging industry sectors [7,11].

5.3. Practical Implications

The proposed evaluation system has several practical implications. For vocational undergraduate institutions, it provides a systematic tool for monitoring teaching quality and supporting evidence-based decision-making. Institutions can identify strengths and weaknesses in curriculum construction, practical teaching, industry collaboration, faculty development, and learning outcomes, thereby implementing targeted improvement strategies [9,10].

For program development, the three-level indicator system facilitates curriculum optimization based on industrial competency requirements. The mapping relationship between industrial demand and educational indicators enables program designers to continuously update curriculum content and practical training activities in response to technological advancement [6]. From the perspective of industry–education integration, the framework encourages deeper enterprise participation in quality assurance processes [7]. At the policy level, the proposed system aligns with recent global initiatives for reforming vocational education systems and may provide useful references for quality assurance and professional cluster construction [4,12]. These directions are consistent with international policy frameworks advocating future-ready vocational education and training systems [18]. In China, the government has recently accelerated comprehensive reforms of the modern vocational education system, with specific emphasis on quality assurance mechanisms for undergraduate-level vocational programs [19].

5.4. Limitations and Future Research

Several limitations should be acknowledged. First, this study focuses on the ICNEV Professional Cluster as a representative case. Further empirical validation across different professional clusters and institutional contexts would strengthen generalizability. Second, the evaluation system was developed primarily through Delphi and AHP; future studies may integrate additional quantitative approaches such as fuzzy comprehensive evaluation or structural equation modeling to improve robustness [13]. Third, technological innovation within the ICNEV industry continues

to accelerate, and evaluation indicators should be periodically reviewed through sustained school–enterprise collaboration [1,2]. Industry analyses confirm that Chinese automotive sector continues to undergo unprecedented transformation, with evolving talent demands across the entire NEV value chain that require sustained educational responsiveness [20].

Future research may investigate digital quality assurance platforms supported by artificial intelligence, educational big data, and learning analytics. Such technologies could establish real-time monitoring systems providing more dynamic and evidence-based support for teaching quality improvement in vocational undergraduate education [8,15].

6. Conclusions

This study proposed an industry demand-oriented teaching quality evaluation system for vocational undergraduate education, using the ICNEV Professional Cluster as a representative case. Guided by OBE, competency-based education, and industry–education integration, a systematic evaluation framework was established linking industrial demand, occupational competencies, talent cultivation objectives, curriculum systems, teaching implementation, practical teaching, and learning outcomes.

A three-level evaluation index system comprising six Level I indicators, twenty-four Level II indicators, and seventy-two Level III indicators was constructed. The Delphi method was employed to optimize the indicator system through expert consultation, while AHP provided a structured approach for determining indicator weights and establishing the comprehensive evaluation model, enhancing both scientific validity and operational feasibility [13].

The study makes three primary contributions: introducing industrial competency requirements as the starting point for teaching quality evaluation [6]; developing a multidimensional evaluation system for interdisciplinary professional clusters; and establishing a multi-stakeholder evaluation mechanism supporting continuous quality improvement [5,10]. The framework provides vocational undergraduate institutions with an operational tool for evaluating teaching quality, optimizing curriculum systems, strengthening engineering practice, and promoting industry – education collaboration [7,11].

The findings indicate that teaching quality evaluation should evolve toward a more dynamic, competency-oriented, and industry-responsive quality assurance system. By strengthening alignment between educational processes and industrial competency requirements, vocational undergraduate institutions will be better positioned to cultivate high-level technical professionals supporting innovation-driven industrial development. Future research should continue validating and refining the proposed framework through empirical application and explore the integration of digital technologies into educational quality assurance.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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