Research and Practice on Teaching Quality Evaluation System in Vocational Colleges in the Age of Artificial Intelligence: Taking the Electromechanical Integration Professional Group as an Example

Juhua Chen
Chongqing Industry and Trade Polytechnic, Chongqing, China

Abstract: The development of artificial intelligence technology and the acceleration of industrial upgrading, higher requirements have been put forward for the quality of talent cultivation in vocational colleges, the traditional teaching quality evaluation system faces challenges such as a single evaluation subject, lagging content, and static methods. This study takes the electromechanical integration technology professional group as an example, a new teaching quality evaluation system based on "student-centered, collaborative across all parties, and data-driven" has been established. This system innovatively integrates a multi-party collaborative evaluation mechanism involving "public authorities, university, enterprise, and industry", reconstruction of competency-based evaluation criteria based on typical work tasks, and an intelligent evaluation data ecosystem of "monitoring-diagnosis-optimization". Through practice, an evaluation scheme has been established, where practical assessment accounts for no less than 50% and enterprise evaluation weighs 40%, the evaluation paradigm has shifted from an empirical to a scientific one, it provides an operable path and case for empowering AI in the reform of vocational education teaching quality evaluation.

Keywords: Artificial Intelligence; Vocational College; Teaching Quality Evaluation; Mechatronics; Data-Driven

1. Introduction

Educational evaluation serves as a crucial fulcrum for guiding the development of education, the teaching quality evaluation system plays a pivotal role in ensuring the quality of technical and skilled talent cultivation. Currently, China's vocational education is currently at a crucial stage of enhancing quality, fostering excellence, and adding value and empowerment, policy documents such as *Opinions on Promoting the High-quality Development of Modern Vocational Education* explicitly state the need to "improve the quality evaluation system". Against the backdrop of continuous penetration of artificial intelligence technology and deepening industrial upgrading, the demand for job competencies exhibits characteristics of dynamic evolution, this has raised higher demands on vocational college students in terms of their composite skills, innovation literacy, and professional adaptability [1,2]. However, many vocational colleges still adhere to the traditional teaching quality evaluation system, there is a widespread structural limitation of "emphasizing three and neglecting three": the emphasis is on internal evaluation with insufficient participation from enterprises, a preference for theoretical knowledge with a low weighting on practical abilities and a focus on summative results while neglecting process-based developmental evaluation [3,4]. This evaluation model struggles to systematically and accurately reflect students' true professional competency levels and individual growth trajectories, it also restricts the effective connection between talent cultivation and industry demand.

In recent years, the academic community has made considerable progress in evaluating teaching quality: evaluation model based on the OBE (Outcome-Based Education) concept, emphasis is placed on designing an evaluation system in a reverse way, centered around students' learning outcomes, emphasize ability achievement and goal leadership [3,5]; the "post-curriculum-competition-certificate" integration model focuses on the deep integration of curriculum with positions, competitions, and certificates, focus on value-added evaluation of students' comprehensive literacy [6]; the integration of "teaching-learning-assessment" focuses on real-time feedback and dynamic adjustment of assessment in the teaching process, teaching benefits from evaluation. Promote learning through evaluation [7]. Meanwhile, the application of artificial intelligence technology has provided new possibilities for teaching quality evaluation, such as achieving deep mining of evaluation data, holographic recording of the entire teaching process and dynamic optimization of evaluation criteria [2,8]. However, Existing research mostly focuses on general theoretical discussions or the application of single technical tools, there is a lack of systematic exploration on how to organically integrate the collaborative mechanism of multiple stakeholders, competency-based evaluation criteria, and intelligent data ecosystem, especially, in-depth practical research on specific professional groups such as mechatronics still needs to be strengthened.

Based on the aforementioned background, this study, selecting the electromechanical integration technology professional group as the specific research object, we should focus on answering the core question of "how to construct a teaching quality evaluation system for vocational colleges that meets the needs of industrial development in the era of artificial intelligence". Focusing on the three key dimensions of "theoretical framework - mechanism design - technical support" in the construction of evaluation system, by combining theoretical exploration with practical verification, we are committed to developing a set of reform paths for vocational education teaching quality evaluation that possess replicable and scalable value.

2. Core Concepts and Theoretical Foundations

2.1 Evaluation of Teaching Quality in the Era of Artificial Intelligence

Evaluation of vocational education teaching quality in the era of artificial intelligence, it refers to the context of the deep integration of intelligent technology and education and teaching, it aims to promote students' comprehensive development and enhance their career adaptability, relying on methods such as multi-agent collaboration, multi-source data fusion, and intelligent algorithm analysis, conduct systematic value evaluation on the process and effectiveness of teaching activities, and form a dynamic evaluation system with a continuous optimization mechanism [2]. The core characteristics of this evaluation system are as follows: evaluation data possesses holographic and real-time characteristics, the evaluation model demonstrates personalization and adaptability, evaluation feedback possesses precision and serves as a forward-looking guide.

2.2 "Student-Centered" Evaluation Philosophy

"Student-centeredness" is the fundamental direction of educational evaluation reform in the new era [4,9]. In the context of vocational education, this concept is embodied in the idea of "centering on students' career development", it not only emphasizes students' mastery of knowledge and skills, we place greater emphasis on portraying the dynamic trajectory of students' skill development through evaluation and stimulating their learning potential, and make a forward-looking prediction on their adaptability to future positions. Evaluation should play the role of a "navigator" that helps students understand themselves, plan their careers, and achieve sustainable development, instead of merely serving as a "judgment document" for grading.

2.3 Diverse Collaboration and Data-Driven Theory

The theory of multi-stakeholder collaboration advocates for the joint participation of multiple stakeholders, including the government, schools, enterprises, and industries, in the evaluation process, by forming a joint force of governance, ensure the authority of evaluation and its guiding role in education and teaching [10]. The data-driven theory emphasizes that, based on in-depth analysis of large-scale and multi-dimensional teaching and training data, it can reveal potential patterns that are difficult to detect with traditional evaluation methods, promote the shift of evaluation from relying on vague judgments based on experience to scientific decision-making supported by evidence [2,11]. The organic combination of the two, it is of crucial significance to construct an evaluation system that meets the development needs of modern vocational education.

3. Construction of an Evaluation System Based on "Student-Centered, Collaborative Across all Parties, and Data-driven" Principles

The evaluation system constructed in this study comprises three core pillars: a diversified and collaborative evaluation mechanism, competency-based evaluation criteria, and an intelligent data ecosystem. The three are interrelated, jointly serve the overall goal of "enhancing the quality of talent cultivation in the electromechanical integration professional group".

3.1 Innovate an Intelligent Evaluation Mechanism Featuring the "Government-University-Enterprise-Industry" Quadripartite Collaboration

Addressing the current issues of a relatively single evaluation subject and the disconnection between industry and education evaluation, this study has established a four-in-one closed-loop collaborative mechanism encompassing "policy guidance, standard alignment, evaluation implementation, and quality improvement". This mechanism clarifies the roles and functions of all parties involved: relevant government departments (such as those in charge of education, industry, and information technology) are responsible for providing policy guidance (such as incentive mechanisms for enterprises to participate in evaluations and honor assessments) and macro-level quality supervision; vocational colleges, as the main implementing entities, primarily responsible for organizing daily teaching evaluations, integrating multi-source data, and implementing improvement measures; intelligent manufacturing enterprises are deeply involved in the evaluation process, provide authentic job competency requirements, participate in practical assessment design and certification, and appoint technical personnel as "corporate mentors" to conduct process evaluation; the Electromechanical Industry Association plays a role as a bridge and a standard leader, develop industry-recognized skill certification standards, and assume the responsibilities of third-party evaluation and dynamic revision of standards.

In terms of collaborative pathways and mechanism innovation, by signing the quadripartite cooperation agreement, clarify the rights, responsibilities, and interests of each party involved. On this basis, develop a "smart contract-driven evaluation system" based on blockchain technology, store key information such as enterprise evaluation tasks, industry standard updates, and student skill achievements (such as virtual debugging records and practical operation process videos) on the blockchain for certification, ensure the credibility of the evaluation process and the traceability of the results. Meanwhile, implement the "corporate evaluation and scoring system", quantify the depth and frequency of enterprise participation in evaluation as points, and it is linked to government project application support, priority recommendation of graduates by institutions, and other rights and interests, thus, the enthusiasm of enterprises to participate can be effectively mobilized. This mechanism aims to increase the weight of enterprise evaluation in the comprehensive evaluation of students from the current generally less than 20% to over 40%, ultimately, it achieves continuous dynamic alignment between evaluation results and industry job requirements.

3.2 Reconstruct the Competency-Based Evaluation Criteria for "Three-Dimensional Linkage and Integrated Integration"

Addressing the current issues of evaluation content emphasizing theory over practice and being disconnected from real job requirements, the study has constructed an evaluation standard system that covers three dimensions: job competency, evaluation mode, and standard alignment. The specific content is as follows: the specific content is as follows:

Job competency dimension: conduct in-depth analysis centered around typical work tasks such as industrial robot operation and maintenance, PLC programming and system debugging, and intelligent production line installation and maintenance, deconstruction has formed more than 100 core skill points, based on this, a detailed "task-capability" comparison table and an electromechanical job skill map will be compiled.

Evaluation mode dimensions: integrate multiple evaluation methods, build an evaluation chain that covers the entire teaching process. Utilizing technologies such as digital twins and VR/AR, conduct process-oriented and exploratory evaluations on PLC programming logic, robot offline simulation, and other related content; in the practical training session, with the help of IoT sensors and motion capture devices, conduct practical assessments on the assembly and adjustment accuracy as well as operational standardization of electromechanical equipment; meanwhile, in alignment with the 1+X certificate standards, such as "Integrated Application of Industrial Robots" and "Intelligent Production Line Control and Maintenance", carry out integrated comprehensive ability certification.

Standard alignment dimension: establish a modular mapping relationship between the "1+X" certificate standards, national occupational standards, and professional course content, promote the implementation of "integration of curriculum and certification". In combination with the development trend of industrial technology (such as the technological evolution from traditional PLC to industrial internet edge control), approximately 20% of the evaluation indicators and content are dynamically updated every semester. In addition, it is explicitly required that the proportion of practical assessment in the evaluation of professional core courses should not be less than 50%, to ensure that the evaluation system focuses on cultivating students' core professional abilities.

3.3 Build an Intelligent Evaluation Data Ecosystem Featuring "Monitoring-Diagnosis-Optimization"

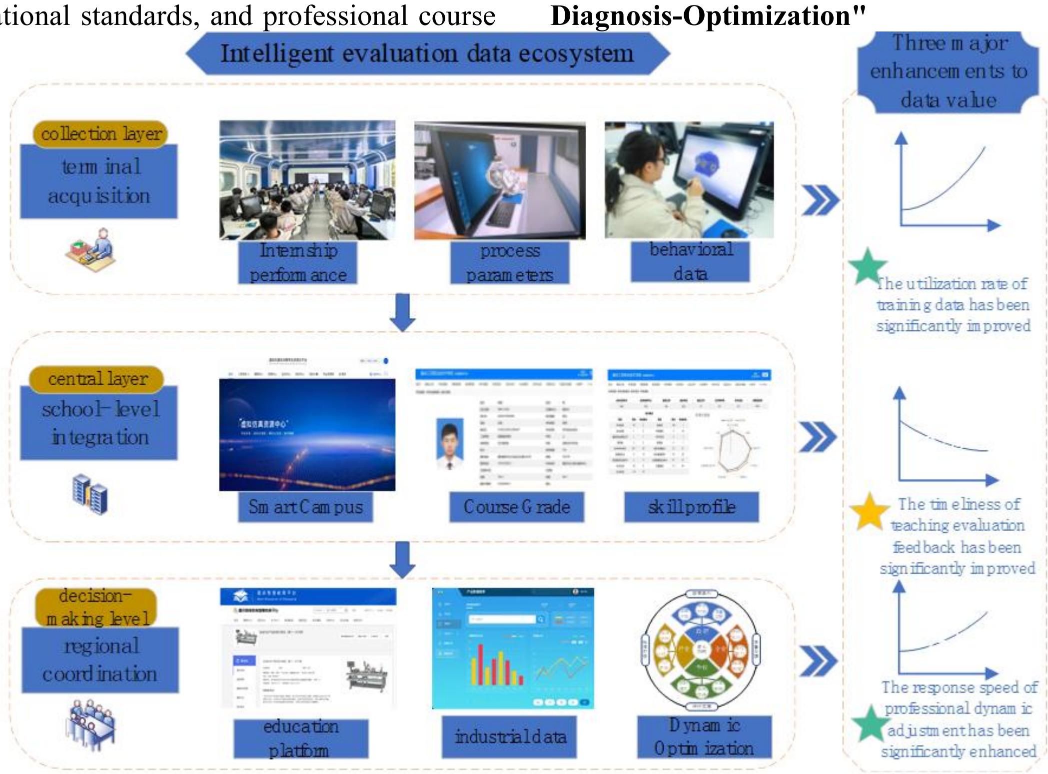

Figure 1. Intelligent Evaluation Data Ecosystem Map

To address issues such as data silos and superficial analysis, this study has established a three-tiered data ecosystem, encompassing "terminal collection, school-level integration, and regional collaboration". The specific structure of the system is as follows: terminal intelligent acquisition layer: upgrade the existing PLC training platform, industrial robot workstation, etc. with IoT technology, add intelligent sensors, and deploy a VR simulation system, realize real-time and seamless collection of procedural data such as student programming code, device operating parameters, operation trajectories, and fault diagnosis logic, gradually establish a dynamically updatable personal "digital skill profile" [12]. School-level data fusion layer: relying on the school's smart campus platform or establishing a new MES teaching management system, develop a data fusion engine, break down the barriers between theoretical teaching (smart classroom data), practical training teaching (IoT collected data), and enterprise internship (mini-program feedback data), support cross-dimensional correlation analysis and comprehensive evaluation. Regional collaborative decision-making level: access to regional big data platforms for smart manufacturing industry-education integration (such as the database of the Chongqing Smart Manufacturing Industry-Education Alliance), apply big data analysis and machine learning algorithms, implement the following functions: firstly, carry out diagnosis and feedback, automatically generate personalized diagnostic reports that cover students' strengths, weaknesses, and suggestions for improvement, and push it to students, teachers, and corporate mentors; Secondly, promote prediction and optimization, by analyzing the correlation between changes in regional industrial talent demand and evaluation data, provide a basis for professional dynamic settings and course content updates, promote a response speed increase of over 50% in professional adjustments to industrial demands. The entire system employs privacy-preserving computing technologies such as federated learning, ensure the orderly flow of data value while safeguarding the data security of all participating parties. (Details are shown in Figure 1)

4. Practical Application and Effectiveness Analysis (Taking the Electromechanical Major Group in a Higher Vocational College as an Example)

The system constructed in this study has been practiced for two years in the Mechatronics Technology major group at X Higher Vocational College.

4.1 Implementation Path

Phase 1 (Construction of the Quadripartite Collaboration Mechanism): Jointly establish a special working group, jointly formulate cooperation regulations and incentive measures. Develop and deploy lightweight evaluation tools based on WeChat Work/DingTalk, significantly reduce the threshold for enterprises to participate, technical personnel in enterprises can conveniently conduct remote evaluation and scoring of student internship projects and works submitted online, evaluation data is synchronized to the system in real time. Introduce a blockchain-based certificate storage mechanism, conduct credible verification and certification for key achievements such as students' competition entries and innovative projects, ensure the traceability of intellectual property rights and the credibility of the evaluation process.

Phase 2 (Integration of Virtual Simulation and Physical Operation): Based on the reconstructed "task-capability" comparison table, systematically revise the evaluation schemes for five core professional courses, including "Modern Electrical Control Technology". In the implementation of the curriculum, Students are required to complete the workstation layout design and collision detection analysis in the virtual simulation environment (included in the process evaluation), then, conduct accuracy calibration and process debugging on the physical equipment (included in the scope of practical operation assessment), ultimately, it can be integrated with the corresponding level of 1+X vocational skill certificate certification (achieving a closed-loop result evaluation).

Phase 3 (Data-driven Teaching Optimization): Establish a teaching big data center for professional clusters, carry out in-depth analysis and application of teaching data. Through cluster analysis of PLC programming data from multiple generations of students, the communication instructions for specific brand controllers were identified as high-frequency error points, and the teaching team adjusted the teaching focus and strategies accordingly; meanwhile, based on the correlation analysis between regional industrial talent demand data and graduate competency evaluation data, the system provides early warning of the increasing demand for "machine vision application" skills, promote the timely addition of corresponding elective course modules within the professional clusters.

4.2 Initial Results

Enhanced synergy in evaluation mechanisms: the number of enterprises participating in the cooperation has expanded from 8 to 22, corporate mentors participate in teaching evaluations more than 800 times annually, the weight of enterprise evaluation in the comprehensive evaluation remains stable at 42%, the depth and breadth of enterprise participation have been substantially enhanced.

Evaluation criteria are more closely aligned with the industry: the average proportion of practical assessment in the core courses of the professional group has been increased to 55%, the proportion of graduates obtaining relevant 1+X vocational skill level certificates has increased from 35% to 78%, the average adaptation period for students after joining the workforce has been shortened by approximately 1.5 months.

Enhanced scientific level of evaluation and decision-making: the personalized ability diagnosis report based on data analysis covers all students, the relevance and effectiveness of teachers' teaching improvement based on diagnostic results have been significantly enhanced. Relying on systematic predictive analysis, the professional group has successfully applied for a new professional direction of "Industrial Internet Technology", the comprehensive utilization rate of training data has increased by over 200%.

Significant achievements have been made in the quality of talent cultivation: the number of awards won by students in national intelligent manufacturing skill competitions has doubled, the employment rate of graduates in their relevant fields and their average starting salary have both seen significant increases, the satisfaction of employers towards graduates has increased from 86% to 94%.

5. Conclusions and Prospects

This study addresses the practical dilemmas of teaching quality evaluation in vocational colleges in the context of artificial intelligence, taking the mechatronics technology professional group as the practical object, the system has designed and implemented a new evaluation system. Break through the institutional barriers of multi-agent collaboration through mechanism design, relying on standard reconstruction, we aim to promote the synchronous updating of evaluation content and industrial development, utilize technological means to achieve intelligent evaluation processes and scientific decision support. Practice shows that, this system effectively promotes the closed-loop operation of "teaching-learning-evaluation-improvement", it has significantly enhanced the pertinence and adaptability of technical skill talent cultivation.

However, the sustainable development of this system still faces several challenges: firstly, the iterative upgrading of intelligent training equipment and data platforms requires continuous resource investment; secondly, the long-term mechanism for enterprises and industry experts to deeply and continuously participate in evaluation needs to be further strengthened at the institutional and incentive levels; thirdly, issues related to data ethics, privacy protection, and information security in the evaluation process urgently require the establishment of a more comprehensive regulatory framework. Looking ahead, the research will delve into exploring the potential applications of Artificial Intelligence Generated Content (AIGC) in automatically generating evaluation scales and intelligently reviewing open-ended practical tasks, and gradually expand this system framework to other engineering discipline groups, provide more practical references and path accumulation for constructing a vocational education quality evaluation paradigm with characteristics.

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