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Reform of the Evaluation Model for Higher Vocational Physics Courses Based on Modular Teaching

Xiaolei Yang*, Jiawei Zhao, Yan Chen, Sufan Tian, Fuqian Wang

Sichuan Southwest Vocational College of Civil Aviation, Chengdu 610400, China

**Author to whom correspondence should be addressed.*

Abstract: The deepening of higher vocational education reform has been progressing steadily, and the talent cultivation model centered on vocational capabilities has become increasingly mature. As an important basic course for science and engineering majors in higher vocational colleges, college physics plays a foundational role in cultivating technical talents. However, its traditional unitary and summative evaluation model of "one exam determining success" can hardly meet the needs of cultivating high-quality technical and skilled talents. By reconstructing the content of college physics courses and based on the modular teaching model, this paper analyzes the main problems existing in the current evaluation of higher vocational college physics courses, and constructs a diversified "trinity" evaluation system integrating process evaluation, outcome evaluation, and value-added evaluation. This system emphasizes the diversification of evaluation subjects, the comprehensiveness of evaluation content, and the variety of evaluation methods, and has been applied in teaching practice in a higher vocational college. The practical results show that this system can effectively stimulate students' learning initiative, promote the coordinated development of their physical knowledge, practical skills, professional literacy, and innovative capabilities, and has positive significance for improving the quality of talent cultivation in higher vocational education.

Keywords: Higher vocational education; Modular teaching; College physics; Trinity; Diversified evaluation; Teaching reform

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1. Introduction

China's higher vocational education aims to cultivate high-quality technical and skilled talents who meet the needs of the modern industrial system. The National Vocational Education Reform Implementation Plan ("20 Vocational Education Articles") clearly points out that vocational education should "transform from following the general education school-running model to a type of education with enterprise and social participation and distinct professional characteristics", and "strive to cultivate high-quality workers and technical and skilled talents" [1]. This series of policies determines that higher vocational education must be closely connected with the needs of professional positions, with the formation of students' vocational capabilities as the core goal. As a basic course for engineering majors, the teaching goal of college physics not only requires students to proficiently master classical physics theories but also, more importantly, to cultivate students' practical abilities such as transforming mechanical, electromagnetic, and other theoretical principles into equipment operation, process optimization, and technical fault diagnosis [2].

However, the current physics course evaluation in many higher vocational colleges still generally adopts the method of final closed-book exams [3]. This single evaluation model has many drawbacks:

First, it emphasizes knowledge over abilities. Higher vocational students are more inclined to intuitive thinking and practical interests. The traditional "lecture-learning-practice" cramming teaching method cannot mobilize students' subjective initiative in learning. Evaluating higher vocational students' college physics learning solely through final exam results cannot effectively measure key vocational abilities, such as students' practical operation, problem-solving, and teamwork [3].

Second, it emphasizes results over processes. Higher vocational education has a diverse source of students, including single-admission students, college entrance examination students, and retired soldiers, leading to significant differences in students' learning abilities [4]. The existing evaluation model ignores students' efforts, progress, and individual differences in the learning process.

Third, the evaluation subject is single. Teachers are the only evaluators. Although students' course scores are not subject to teachers' will, there is a lack of students' self-reflection and peer evaluation, not to mention the participation of industry and enterprises. This evaluation model cannot mobilize students' learning enthusiasm, and to a certain extent, will suppress students' subjective initiative, which is contrary to the talent cultivation goal of higher vocational education [5]. Therefore, based on the single evaluation model, this paper reconstructs the content of higher vocational college physics courses. Taking the aircraft electromechanical equipment maintenance major as an example, the course content is divided into two major modules: mechanics and electromagnetism. On this basis, the course content is subdivided to construct a diversified evaluation system based on modular teaching, taking this as a breakthrough to reconstruct the evaluation model of higher vocational college physics courses, forcing the reform of the teaching model, and thus realizing the transformation of physical theories into practical abilities.

2. Connotation of modular teaching and diversified evaluation

2.1. Modular teaching

The essence of modular teaching is a competency-based and learner-oriented teaching model. In this curriculum reform, we define its core concept as: breaking the traditional knowledge system of college physics based on disciplinary logic, and reconstructing the course content into several relatively independent yet organically connected "teaching modules" according to the talent cultivation goals of higher vocational majors and students' subsequent development needs [6]. Specifically, each module is a complete learning unit, including clear learning objectives, selected teaching content, supporting teaching activities, and targeted evaluation plans [7]. In this study, the course is designed into three levels: "basic theory module," "professional technology application module," and "expansion and innovation module" (**Figure 1**). Among them, the "basic theory module" ensures that students master the necessary basic physical knowledge; the "professional technology application module" is deeply integrated with different professional directions (such as electromechanical, aircraft maintenance, aircraft manufacturing, etc.), selecting thematic content such as mechanics and machinery, electromagnetism and circuits, highlighting the practical application of physical principles in engineering technology; the "expansion and innovation module" focuses on scientific frontiers, physics history, or daily physics, aiming to cultivate students' scientific literacy and innovative awareness. Through this modular reconstruction, the course has achieved a transformation from "knowledge infusion" to "ability cultivation" and from "disciplinary closure" to "professional openness," laying a solid foundation for the implementation of diversified evaluation [6].

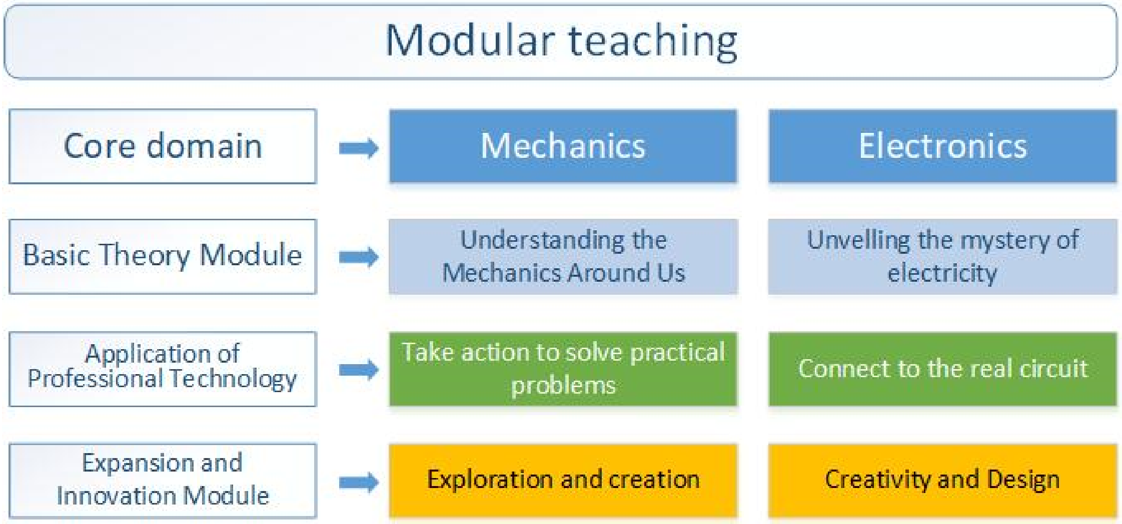

Figure 1. Display of the modular teaching content framework.

2.2. Diversified evaluation

According to the connotation of modular teaching, this study proposes the concept of diversified evaluation. Diversified evaluation refers to the innovation of the traditional single evaluation model, with its core lying in "diversification", that is, diversified evaluation objectives, diversified evaluation content, diversified evaluation subjects, diversified evaluation methods, and diversified evaluation processes [8] (**Figure 2**).

Among them, diversified evaluation objectives mean shifting from simply examining the mastery of physical knowledge to a comprehensive evaluation of multiple dimensions such as knowledge understanding, skill application, scientific literacy, innovative thinking, and professional attitude.

Diversified evaluation content covers theoretical learning, experimental operation, project practice, classroom performance, extracurricular expansion, and other aspects.

Diversified evaluation subjects mean constructing a multi-subject evaluation network combining teacher evaluation, student self-evaluation, group mutual evaluation, and enterprise mentor evaluation (such as participating in project review).

Diversified evaluation methods mean comprehensively using various methods such as tests, experimental reports, project works, oral defenses, observation records, and portfolio evaluation.

Diversified evaluation processes mean integrating evaluation throughout the entire teaching process, realizing the organic combination of diagnostic evaluation, formative evaluation, and summative evaluation [8].

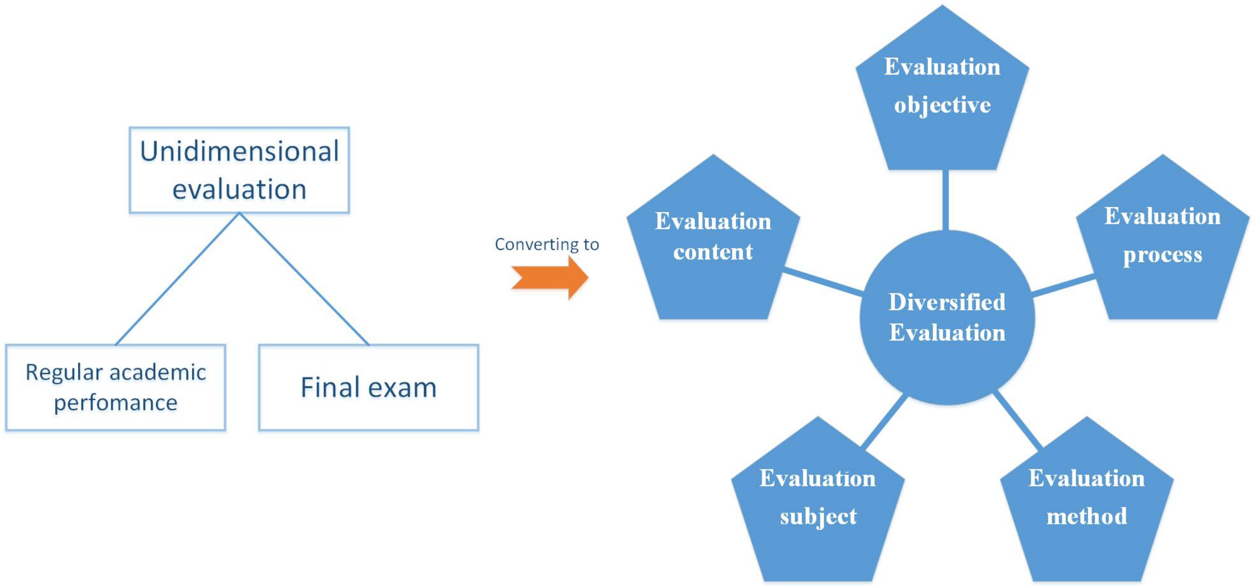

Figure 2. Comparison chart of diversified evaluation.

3. Construction of the "Trinity" diversified evaluation system

Based on the above concepts, taking the content of the college physics course learned by the electromechanical maintenance major in the Aircraft Maintenance College of Sichuan Southwest Aviation Vocational College as an example, we construct the following "trinity" diversified evaluation system model (**Figure 3**), with specific components as follows:

3.1. Process evaluation: Focusing on growth and habits

Process evaluation aims to provide timely feedback on students' learning status, enable teachers to perceive the key and difficult problems encountered by students in learning, solve them promptly, and provide improvement ideas for subsequent course teaching to continuously optimize teaching quality [9].

Process evaluation accounts for 40% of the entire evaluation system, among which pre-class preparation accounts for 10%, including the learning of pre-class video knowledge and the completion of pre-class knowledge tests. The Superstar Learning Platform is used to record students' learning status. Quality achievements account for 10%, including teamwork, safety knowledge, craftsmanship spirit, information literacy, innovative awareness and ability, etc. [10–12], evaluated by teachers, intra-group mutual evaluation, and student self-evaluation. In-class skill learning accounts for 20%. The Superstar Learning Platform is used to record chapter tests, online discussions, etc., to realize the timely consolidation and diagnosis of knowledge points. In this diversified evaluation system, process evaluation occupies a dominant position, and the evaluation focus shifts from participation in answering questions in class to pre-class preview, teamwork, data analysis ability, and the quality of completing group assignments.

3.2. Value-added evaluation: Encouraging innovation and individuality

Value-added evaluation accounts for 30%, aiming to respect students' individual differences and encourage potential development and innovative spirit [13,14]. Due to the wide range of students in higher vocational colleges, including single-admission students, college entrance examination students, and retired soldiers, the students' foundations are uneven. Therefore, the focus of value-added evaluation is to include students' progress in the course learning process into the evaluation, thereby solving the evaluation contradiction caused by different learning foundations.

Among them, we innovatively incorporate physical innovation works and learning portfolios [15]. Physical innovation works refer to encouraging students to create small physical inventions, write popular science essays or research reports, and those who complete them can get extra points. Learning portfolios refer to students independently collecting key materials that can represent their learning process and progress (such as the best experimental reports, project plans, reflection logs, etc.) [16], which are displayed and summarized at the end of the semester as a reference for evaluation.

3.3. Outcome evaluation: Focusing on application and output

Outcome evaluation accounts for 30%, paying more attention to the assessment of students' phased and final learning outcomes [17]. However, different from the previous traditional final exams, we decompose outcome evaluation into modular project tasks and final written exams. Among them, modular project tasks account for 20%, designing physics application projects related to the major, or designing a small physical experiment to verify a physical principle. It is completed in groups, and project reports are submitted and defended, with comprehensive scores given by teachers and group mutual evaluation. The final comprehensive exam accounts for 10%. The content of the written exam is reformed, greatly reducing memory-based and computational questions, and increasing principle application questions, phenomenon analysis questions, case analysis questions, combined with the major, etc., focusing on examining the ability of knowledge transfer and solving practical problems.

<table>
<tr><td rowspan="2">Evaluation Process</td><td colspan="2">Process Evaluation (40%)</td><td colspan="6">Value-Added Evaluation (30%)</td><td colspan="7">Outcome Evaluation (30%)</td></tr>
<tr><td colspan="3">Pre-class (10%)</td><td colspan="4">In-class (50%)</td><td colspan="5">Post-class (20%)</td><td colspan="3">Final Assessment (20%)</td></tr>
<tr><td>Outcome Type</td><td>Knowledge Outcome (5%)</td><td>Skill Outcome (5%)</td><td colspan="5">Quality Outcome (10%)</td><td colspan="5">In-class Skills + Post-class Consolidation (60%)</td><td colspan="2">Knowledge Outcome (10%)</td><td>Skill Outcome (10%)</td></tr>
<tr><td rowspan="2">Evaluation Method</td><td colspan="2">Self-study Before Class (10%)</td><td colspan="5">Quality Outcome Evaluation (10%)</td><td colspan="2">Mechanics Module(20%)</td><td colspan="2">Electronics Module(20%)</td><td>Professional Literacy (20%)</td><td>Post-class test (5%)</td><td>Final exam (theory + practice) (5%)</td><td>Final outcome report (10%)</td></tr>
<tr><td>Pre-class video knowledge learning (5%)</td><td>Pre-class knowledge test completion (5%)</td><td>Teamwork (2%)</td><td>Safety awareness (2%)</td><td>Craftsman spirit (2%)</td><td>Information literacy (2%)</td><td>Innovation awareness & ability (2%)</td><td>Knowledge evaluation: Class discussion, post-class assignment completion (10%)</td><td>Skill evaluation: Project practice (e.g., simple mechanical device design/assembly, maintenance skill training) (10%)</td><td>Knowledge evaluation: Case analysis of household circuits, phased test of electrical knowledge (10%)</td><td>Skill evaluation: Project practice (electrical training project development) (10%)</td><td>1. Safety standard awareness: Correct & safe use of experimental equipment;2. Team collaboration awareness: Teamwork in group tasks;3. Innovation ability: Optimized mechanical structure/ circuit design</td><td>Post-class test</td><td>Final exam: Questions combining college physics theory & practice (5%)</td><td>Project report, training report, skill certificate, competition awards, etc.(10%)</td></tr>
<tr><td>Evaluation Subject</td><td colspan="2">Teacher evaluation</td><td colspan="5">Teacher evaluation, intra-group peer review, student self-evaluation</td><td colspan="5">Teacher evaluation, intra-group peer review, training teacher review, student self-evaluation</td><td colspan="2">Teacher evaluation</td><td>Teacher evaluation, intra-group peer review</td></tr>
</table>

Figure 3. "Trinity" diversified evaluation system model.

4. Teaching practice and effect analysis

This study conducted a one-semester practice in two parallel classes of the 2024-level electromechanical maintenance major in the Aircraft Maintenance College of Sichuan Southwest Aviation Vocational College. Among them, Class A (60 students) adopted the traditional evaluation model of "50% usual performance + 50% final exam," and Class B (58 students) implemented the above-mentioned diversified evaluation system.

4.1. Practice process

In the teaching of Class B, relying on the Superstar online teaching platform, we implemented the following processes:

(1) Pre-class: Issue task lists and micro-course videos, and students complete online preview and tests (process evaluation records).

(2) In-class: Carry out group discussions and inquiry activities, and teachers observe and record (process evaluation). Introduce enterprise cases for analysis.

(3) Post-class: Complete online assignments and finish a professional-related project task in groups (outcome evaluation).

(4) End of semester: Conduct comprehensive written exams (outcome evaluation) and organize learning portfolio sorting (value-added evaluation).

4.2. Effect analysis

Through questionnaire surveys, score comparisons, and teacher-student interviews at the end of the semester, the following findings were obtained:

(1) Score comparison: There was no significant difference in the average score of the final written exam between Class B and Class A, but Class B performed significantly better than Class A in links reflecting comprehensive abilities, such as project defense and experimental reports. The excellent rate and pass rate of the overall evaluation score of Class B were higher than those of Class A.

(2) Learning interest and attitude: The questionnaire showed that more than 85% of the students in Class B believed that diversified evaluation could better stimulate learning interest, make themselves pay more attention to daily learning and practice processes, and the distribution of learning pressure was more balanced.

(3) Self-evaluation of ability improvement: The self-evaluation scores of students in Class B in terms of "problem-solving ability," "teamwork ability," "expression ability," and "innovative thinking" were significantly higher than those in Class A.

(4) Teacher feedback: The teachers believed that although diversified evaluation increased the initial workload, it could help them understand each student more comprehensively and in-depth, making teaching more targeted. The classroom atmosphere and students' participation were significantly improved.

5. Discussion

Practice has proved that the diversified evaluation system based on modular teaching has effectively reversed the tendency of "only focusing on scores", transforming evaluation from a "sieve" into a "pump," which fulfilling the functions of motivation, diagnosis, and development, and promotes the coordinated development of students' knowledge, abilities, and literacy. However, there are also some challenges in the practice process: first, it puts forward higher requirements for teachers, who need to invest a lot of energy in designing evaluation standards, organizing activities, and recording data; second, how to design project tasks more closely combined with different majors requires the in-depth participation of professional teachers and enterprise personnel; third, the quantification and fairness of diversified evaluation need to be further refined.

In the future, we will deepen the research into the following aspects:

(1) Develop a diversified evaluation management tool deeply integrated with the information-based teaching platform to reduce teachers' workload and realize the automatic collection and analysis of evaluation data.
(2) Strengthen school-enterprise cooperation, invite enterprise engineers to participate in the design and evaluation of project tasks, and introduce more realistic professional standards.
(3) Explore the integration of vocational skill level standards in the "1+X" certificate system into physics course evaluation to further enhance the professionalism and authority of evaluation.

6. Conclusion

Constructing a diversified evaluation system for higher vocational college physics based on modular teaching is an inevitable requirement for adapting to the development of vocational education as a type of education. Through the diversification of evaluation objectives, content, subjects, and methods, this system integrates evaluation throughout the entire teaching process, realizing the transformation from "valuing knowledge over ability" to "integrating knowledge and practice." Teaching practice shows that this system can effectively improve students' comprehensive vocational abilities and learning sense of gain, and has important promotion value for deepening the reform of higher vocational physics teaching and improving the quality of technical and skilled talent cultivation.

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Disclosure statement

The authors declare no conflict of interest.

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