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Teaching Exploration of Multi-Dimensional Mixed Specialized Courses to Strengthen Practical Ability--Take the Course "Automobile Performance and Test" as an Example

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Abstract: *In view of the prominent issues in current engineering course teaching, such as the serious disconnection between theoretical teaching and practical application, and the insufficient cultivation of students' innovative ability, this paper puts forward a multi-dimensional mixed teaching mode that focuses on strengthening practical links. Taking the course "Automobile Performance and Test" as a specific practice carrier, this mode breaks the limitations of traditional teaching by establishing an expert teaching team with in-depth school-enterprise cooperation. It constructs a four-dimensional integrated teaching system covering "online knowledge construction-offline topic deepening-project practice empowerment-enterprise resource linkage", which makes up for the lack of attention to multi-level ability training in traditional mixed teaching. Through two years of teaching practice verification, this mode has significantly improved students' professional quality, practical operation skills and innovative problem-solving ability. It not only provides an effective way for students to connect theoretical knowledge with engineering practice, but also offers a referable teaching paradigm for higher engineering education to adapt to the national strategic demand for compound technical talents, and has important promotional value for similar professional course teaching reforms.*

Keywords: *Multi-Dimensional Mixed Teaching, Strengthen Practical Ability, Automobile Performance and Test*

1. Introduction

The core goal of higher engineering education is to cultivate innovative talents with a solid theoretical foundation and comprehensive practical ability, so as to support the strategic needs of national manufacturing transformation and upgrading [1]. However, there are obvious shortcomings in the teaching of traditional professional courses: First, knowledge transfer is mainly based on classroom teaching, and the experimental link is only aimed at isolated knowledge points, which makes it difficult for students to form systematic engineering problem solving ability, Secondly, the curriculum content is out of touch with the actual industry, and students' cognition of cutting-edge technology application is limited to the theoretical level.

The integration of blended learning approaches into curriculum reform has garnered significant attention across various disciplines, emphasizing the enhancement of teaching and research practices. So the hybrid mode of combining a massive open online course with offline teaching has emerged in China in recent years.

According to Katajavuori et al. [2], Finnish pharmacy education has seen notable improvements through curriculum reforms that combine practical training with theoretical studies. The introduction of personal study plans facilitated a more cohesive learning experience, highlighting the importance of blending practical and theoretical components to improve student engagement and learning outcomes. Similarly, Guo et al. [3] discuss the necessity of reforming art major curricula to better align with industry development. Their focus on establishing a practice-oriented teaching philosophy underscores the importance of integrating industry-relevant practice, innovation, and research into the curriculum. This approach aims to mobilize student initiative and enthusiasm, thereby fostering a mode of talent training that combines teaching, innovation, and industry collaboration. Research by Yang [4] emphasizes that task-driven teaching based on blended learning is a key direction for college teaching

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reform. Blended learning, guided by theoretical frameworks and supported by information technology, is recognized as a vital method to enhance educational practices. Ye [5] further supports this view by demonstrating that mobile Internet-based blended teaching in mathematical analysis effectively cultivates autonomous learning, problem-solving skills, and improves overall student performance, indicating the practical benefits of integrating online and traditional teaching methods. Zhao et al. [6] explore the MOOC and flipped classroom models within a blended teaching mode, revealing that such approaches can tailor instruction to student needs, strengthen communication and cooperation, and significantly improve course effectiveness. Similarly, Hu et al. [7] construct a mobile-based hybrid teaching model supported by cloud classrooms and the ADDIE instructional design, which enhances student participation, achievement, and independent learning capabilities. The role of modern technology in labor education is highlighted by Li et al. [8], who argue that integrating Internet technology into labor courses enhances both theoretical understanding and practical skills. Fang [9] extends this discussion by detailing the development of online and offline hybrid courses in big data analysis, illustrating the application of blended learning in specialized fields to create first-class courses. Enoch et al. [10] investigate factors influencing the transfer of online clinical skills training, proposing a blended conceptual model that combines online and onsite components. Their findings suggest that such integration improves learners' ability to transfer knowledge and skills effectively. Lastly, He et al. [11] demonstrate that a production-oriented approach within a blended teaching framework can enhance teachers' application of theoretical knowledge, particularly in cultural translation courses, aligning with curriculum ideological and political education reforms. Project-based teaching (PBL), CDIO and other modes have been widely used in the field of international engineering education to strengthen practice, but there are some shortcomings in the systematic construction of a knowledge system [12]. Previous studies have shown that the single-dimensional teaching reform is difficult to meet the requirements of high-order engineering ability training, and it is necessary to build a three-dimensional teaching system by means of multi-agent cooperation and multi-scene integration.

Overall, these studies collectively underscore that blended curricula—combining online and offline, theoretical and practical elements—are pivotal in advancing teaching and research reform. They facilitate active learning, improve student engagement, and foster skills relevant to industry and societal needs, thereby promoting more effective and practice-oriented educational practices.

Blended learning has optimized the efficiency of knowledge transfer, but the practice links are mostly limited to confirmatory experiments and have failed to form a closed loop of ability training that meets the needs of the industry [13-14].

But the existing mixed teaching mostly stays in the dual structure of "online theory + offline experiment". Although it can give attention to knowledge coverage and basic practice, there is a lack of dimensions in the cultivation of high-level innovation ability [15].

Based on the teaching practice of "Automobile Performance and Test", this paper puts forward a "multi-dimensional mixed teaching mode to enhance practice", aiming at: (1) breaking through the separation of theory and practice in traditional teaching and constructing a progressive training path of "knowledge construction-application deepening-innovative practice", (2) Introducing real engineering problems through school-enterprise cooperation mechanism to improve students' industrial adaptation ability, (3) Provide reproducible methodology and practical cases for the teaching reform of similar engineering courses.

2. Enhance the Multi-Dimensional Mixed Teaching Design of Practice

2.1 Construction of Pattern Framework

This model takes "three-dimensional ability training" as the core, that is, the basic dimension focuses on the construction of a system knowledge system and realizes standardized transmission through an online platform. The application dimension emphasizes the cultivation of knowledge transfer ability and deepens understanding by relying on offline special lectures and case studies. Innovation dimension pays attention to the shaping of engineering problem-solving ability, and realizes the leap of ability through the linkage between project system practice and enterprise resources. The three form a closed loop through the collaborative design of an "expert team-teaching process-assessment system".

The "four-dimensional integrated teaching system" constructed in this paper—comprising online knowledge construction, offline topic deepening, project practice empowerment, and enterprise resource linkage—focuses on dismantling the dualistic fragmentation of traditional blended teaching ("online theory + offline experiments"). By deeply integrating the unique dimension of "enterprise resources," it permeates authentic engineering scenarios, cutting-edge technological demands, and industry standards throughout the entire teaching process.

Online Knowledge Construction (Foundation Dimension) lays the theoretical groundwork for understanding enterprise cases. Offline Topic Deepening (Application Dimension), led by enterprise experts, analyzes the application of theory in complex engineering problems. Project Practice Empowerment (Innovation Dimension) directly connects students to simplified or pre-researched authentic tasks from enterprises, driving them to achieve capability leaps through solving real-world problems.

Enterprise Resource Linkage (Pervasive Dimension) not only provides project sources and mentor support but also transmits the pulse of industrial development to the classroom in real-time, ensuring dynamic synchronization between teaching content and industry needs. This synergistic, spiraling structure of the four dimensions is the key mechanism for addressing the insufficient attention to multi-level competency development in traditional blended teaching.

2.2 Establishment of Expert Teaching Team

In order to ensure the realization of multi-dimensional teaching objectives, an expert team across schools and enterprises is set up. As shown in Table 1, its composition reflects three major characteristics.

(1) Structural complementarity. It covers 55-year-old senior professors (responsible for controlling the teaching direction), young and middle-aged teachers aged 33-38 (leading online resource construction and technical teaching), and senior engineers of enterprises (providing industrial perspectives and real projects).

(2) Clear division of functions. Teachers in the school focus on combining the theoretical system and developing teaching resources, enterprise engineers are responsible for screening engineering cases and designing practical projects, and schools and enterprises jointly complete the "industrial adaptability transformation" of teaching content.

(3) Dynamic cooperation mechanism. Establish a biweekly collective lesson preparation system, and ensure the synchronization of teaching and industrial technology development through the linkage process of "enterprise demand investigation-teaching content adjustment-practical project optimization".

The "Dynamic Collaboration Mechanism" of the expert team demonstrates potent efficacy in practice. For example, when preparing the topic "New Energy Vehicle Powertrain Testing," the enterprise engineer (C5) identified the industry pain point: "High-frequency electromagnetic interference from motor controllers contaminating sensor signals." The teaching team immediately activated the linkage process:

The enterprise provided typical interference case data.

University teachers (C2, C3) integrated interference principles and suppression methods into online resources (adding a micro-video "EMC Issues in Testing" and interactive exercises).

Senior professors (C1, C4) adjusted offline content, adding a session on "Anti-Interference Signal Design and Case Analysis."

The team co-designed a tiered practical project. The basic level is to identify interference components in signals. The intermediate level is to design simple hardware filtering solutions. The advanced level explores software algorithm-based interference suppression methods. This process fully exemplifies the team's efficient synergy and complementary strengths in knowledge updating, content reconstruction, and project design.

The role of enterprise engineers C5 extends far beyond case providers. They deeply participate in offline lectures, guiding students with an "engineering mindset" to understand design constraints. During project practice, they act as "industry mentors," providing "cloud guidance" via online platforms to answer practical engineering challenges students face in scheme design, equipment operation, and data processing. Their feedback often targets core engineering principles. This real-time guidance from the industrial frontline is indispensable for enhancing students' "industrial adaptability."

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Table 1 Basic information of experts.

Code	Age	Professional title
C1	55	Professor
C2	33	lecturer
C3	33	lecturer
C4	38	Professor
C5	38	Senior Engineer

3. Teaching Implementation Process

3.1 Preparation of Teaching Resources

(1) Online resource construction. The 24-hour theoretical content is transformed into modular online courses, and the resource system of "video explanation + interactive exercises + literature expansion" is constructed based on the massive open online course platform of Chinese universities. Each knowledge point is matched with three-dimensional materials of "principle animation + equipment disassembly video + engineering application case". For example, in the module of "automobile vibration test", the live video of the automobile engine vibration test and the operation demonstration of signal analysis software are embedded.

(2) Offline practice resource development. School-enterprise jointly developed three special lectures ("Engineering Practice of Automobile Vibration Test", "Signal Analysis in Automobile Test" and "Error Control of Automobile Test") and six practical projects, of which two projects originated from the real test tasks of enterprises (simplified to meet the teaching needs). The six-tiered projects range from foundational ("Brake Performance Bench Verification") to comprehensive ("Acceleration Noise Source Identification and Optimization Suggestions for a Specific Vehicle Model"), with difficulty escalating progressively. The competency requirements evolve from operational standardization to systemic analysis and innovative design. Particularly, the two projects derived from authentic enterprise tasks, while pedagogically adapted, retain the core characteristics of engineering problems. This allows students to confront industrial challenges head-on, honing their ability to solve "authentic problems."

3.2 Teaching Link Design

Adopt the three-stage process of "self-study at the front line of class-deepening at the middle line of class-project practice after class", as follows:

(1) Online knowledge construction before class. The teaching assistant publishes the Learning Task List one week in advance, and clarifies the knowledge point objectives (such as "mastering the principle of acceleration sensor selection"), reference resources (including massive open online course video and literature links) and preview tasks (such as completing the sensor parameter comparison table).

Students learn independently through the platform, ask questions in real time through the discussion area, and teachers focus on answering questions every day, forming a "question-answer" knowledge base for subsequent reference.

(2) Deepening offline ability in class. Dynamic lesson preparation adjustment, according to online learning data (such as video viewing progress, exercise accuracy rate), the teacher team focuses on high-frequency error-prone points to carry out the second stage of collective lesson preparation, and determines the key points of offline teaching.

Special lectures and case studies are mainly for enterprise engineers to explain the logic of automobile test design in combination with real projects. For example, taking "Vibration Test of Powertrain of New Energy Vehicles" as an example, the relationship between sensor layout, data acquisition and fault diagnosis is analyzed. Students are divided into groups to carry out "task disassembly-scheme design-pros and cons debate" around cases, and teachers make heuristic comments. Students choose projects according to their interests (such as "automobile power test"), complete the scheme design under the guidance of their tutors, and use classroom time to evaluate and optimize the schemes among groups.

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(3) Practice and expansion of after-school projects. Students use 4-6 hours to complete practical projects, including test instrument system construction, data collection, result analysis and report writing, and get real-time guidance from tutors through an online platform in the process.

Students organized an exhibition and competition of project achievements adopting the "poster defense + physical demonstration" format. School and enterprise experts jointly evaluated these presentations to strengthen students' project communication skills.

3.3 Assessment and Evaluation System

The whole process multi-dimensional assessment is adopted as shown in Table 2, breaking the traditional mode of "one test determines the result". This assessment system comprehensively evaluates students from multiple learning links and ability dimensions, with specific contents as follows:

Daily homework covers various forms such as sensor selection reports and error analysis assignments. This urges students to consolidate theoretical knowledge and fosters their initial ability to analyze professional issues.

Practical projects are divided into scheme design (5%), test process (5%), report quality (5%), and result display (5%), it assess innovative thinking, operational skills, data analysis, and expression abilities, respectively.

Online learning ensures students' autonomous learning progress, checks knowledge mastery, and encourages interactive learning. Video completion aims to monitor the progress of students' independent learning and ensure that they systematically learn online theoretical knowledge, online tests examine students' mastery of knowledge points through targeted questions and timely feedback on learning effects, discussion participation encourages students to actively engage in online interactions, share learning experiences, raise questions, and answer others' questions, cultivating collaborative learning and critical thinking abilities.

Classroom performance is evaluated by contribution in case studies and enthusiasm in group collaboration, which promotes the improvement of comprehensive literacy through interaction.

Final exam is a closed-book written test that focuses on the application and integration of theories, ensuring students have a solid foundation and strong knowledge transfer ability.

Table 2 Multi-dimensional assessment form of the whole process.

Assessment link	Proportion	Contents and methods of evaluation
Homework at ordinary times	5%	Including sensor selection report, error analysis operation, etc.
Practical project	20%	Scheme design (5%), test process (5%), report quality (5%), results display (5%)
Online learning	20%	Video completion (5%), online test (10%), discussion participation (5%)
Classroom performance	5%	Contribution degree of case study and enthusiasm of group cooperation
Final exam	50%	Closed-book written test, focusing on theoretical application and synthesis

4. Teaching Practice Effect

In two years' teaching practice, compared with the traditional mixed teaching class (control group), the average score difference between the two groups is less than 1 point, but the score rate of "comprehensive case analysis questions" in the experimental group (78%) is significantly higher than that in the control group (62%). Through questionnaires (124 valid samples) and interviews, 89% of students think that "the combination of practical projects and enterprise cases" has significantly improved the ability to solve engineering problems, 76% of the students said that "multi-tutor guidance" helped them establish a knowledge framework for automobile performance and test, 91% of students support the promotion of this model in other engineering courses.

Beyond scores and survey feedback, student behavioral changes better reflect the enhancement of higher-order competencies. During project practice, the 2021 experimental class showed significantly

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higher rates than the control group (approximately 3:1) in:

Proactively consulting industry standards (e.g., ISO vehicle testing norms).

Utilizing specialized software (e.g., MATLAB) for auxiliary analysis.

Attempting interdisciplinary solutions (e.g., applying acoustic metamaterial concepts for sound insulation optimization).

When solving sudden equipment failures or data anomalies during testing, experimental class students demonstrated stronger systemic thinking and debugging resilience, reducing average independent troubleshooting time by 35%. These behavioral shifts validate the effectiveness of the multi-dimensional blended model in fostering "engineering problem-solving capability" and "innovative practice ability." Enterprise mentors noted post-project review: "Experimental class students' schemes are not only more standardized (aligning with corporate report templates) but also demonstrate greater consideration for engineering constraints (e.g., cost, timeline). Some optimization suggestions even have a direct reference value."

5. Conclusion

The multi-dimensional mixed teaching mode constructed in this study effectively makes up for the problem in the cultivation of "knowledge-ability-literacy" in traditional teaching through the team mechanism of school-enterprise cooperation, progressive teaching link design and whole process assessment system. Its core innovations lie in: (1) breaking through the dual mixed mode, adding the dimension of industrial resources, and realizing the deep connection between teaching and engineering practice, (2) Construct the ability training chain from foundation to innovation through gradient project design, (3) Form a replicable methodology of "team building-resource development-process implementation". (4) Establishing the "Four-Dimensional Integrated Teaching System" (online knowledge construction - offline topic deepening - project practice empowerment - enterprise resource linkage). Follow-up research will further expand the scope of practice, explore the application of artificial intelligence technology in personalized learning path recommendation, and continuously optimize the adaptability and effectiveness of the teaching mode.

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