Curriculum and Teaching Methodology (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/curtm.2025.080406
ISSN 2616-2261 Vol. 8 Num. 4

Exploration of Teaching Model Reform in Automotive Fault Diagnosis Courses under the CBL+PBL Concept

Cuicui Wang[1,a,*], Qingqing Hou[1,b]

[1]*School of Noncommissioned Officers, Army Academy of Armored Forces, Changchun, China*
[a]1769108918@qq.com, [b]13234021318@163.com
**Corresponding author*

Keywords: CBL, PBL, Fault Diagnosis, Vocational Colleges, Teaching Reform

Abstract: This paper analyzes the current state and main issues of teaching models for automotive fault diagnosis courses in vocational colleges and proposes an innovative teaching approach that deeply integrates Case-Based Learning (CBL) and Problem-Based Learning (PBL). Taking "abnormal engine oil consumption" as an example, a self-directed learning pathway for fault diagnosis knowledge is constructed through the design of real-case scenario introduction, problem-chain-driven inquiry, role-based group collaboration, and dynamic fault simulation. Practical results demonstrate that this model significantly enhances students' fault analysis skills, inquiry awareness, and teamwork abilities, providing a reference for practical teaching reform in automotive fault diagnosis courses at vocational colleges.

1. Introduction

Vocational education differs from undergraduate education in its focus on competency development as its core. With the advancement of automotive intelligence, fault diagnosis has shifted from experience-dependent methods to data- and logic-driven analytical approaches. Industry surveys reveal that 68% of automotive repair enterprises perceive vocational graduates as having issues such as "rote memorization of theory and disorganized practical logic". The traditional "teacher demonstration, student imitation" teaching model struggles to meet the demands of complex fault diagnosis, necessitating the exploration of competency-oriented pedagogical innovations.

Current challenges in fault diagnosis courses include:

Student-related issues: Vocational students often have weaker foundational knowledge, low learning initiative, insufficient inquiry awareness, and lack innovative thinking. They passively accept solutions without opportunities for self-directed exploration or systematic thinking training.

Teaching method limitations: While new pedagogical concepts are frequently introduced, they often amount to "old wine in new bottles," failing to fundamentally address low student engagement.

Infrastructure constraints: Unlike other courses, fault diagnosis requires scenario-based teaching tailored to real-world failures. However, the vast variety of automotive faults and the difficulty of replicating them without damaging vehicles result in low student participation, ineffective skill development, and insufficient cultivation of higher-order thinking skills.

Misaligned assessments: Overreliance on written exams neglects core competencies such as diagnostic logic and team collaboration, deviating from actual job requirements.

Thus, exploring a teaching model reform under the CBL+PBL concept offers a new pathway for practical, competency-based innovation in vocational automotive fault diagnosis courses.

2. Feasibility Analysis of CBL+PBL Integration

2.1. Conceptual Exploration

CBL (Case-Based Learning) is a teaching method centered on real-world cases[1]. It involves selecting typical cases aligned with course content, allowing students to simulate or recreate scenarios, assume roles within these cases, and lead classroom discussions through group collaboration[2]. This approach emphasizes practice-driven theoretical learning, reinforcing theory through practical application. While it effectively restores professional scenarios through authentic cases, it risks falling into the limitation of "teacher-dominated analysis and passive student acceptance." PBL (Problem-Based Learning) is a student-centered teaching model that focuses on collaborative group analysis of specific fault cases with instructor guidance[3]. Its core philosophy treats problems as the starting point for learning and integrating new knowledge. PBL actively stimulates student motivation, encouraging exploration across multiple knowledge domains. However, when applied to complex system faults, it may lead to "blind trial-and-error" due to insufficient structured guidance[4].

2.2. Synergistic Advantages

In recent years, the concept of "deep teaching" has gained traction, emphasizing active learning, transferable application, and cognitive skill development. Yet, reforms under traditional or superficially updated pedagogical frameworks often represent "old wine in new bottles"-superficial changes lacking true depth. Integrating CBL and PBL addresses this gap: CBL provides structured scenarios, anchoring learning in real-world contexts; PBL fuels exploratory motivation, driving open-ended inquiry. Together, they create a "clear-anchor, open-path" learning framework [5].

By immersing students in collaborative problem-solving tasks, this integration constructs an autonomous inquiry pathway for fault diagnosis knowledge. Extending learning beyond the classroom to lifelong career development, it emphasizes critical thinking refinement at every stage. Through role transformation and iterative practice, students gradually develop systematic diagnostic thinking, achieving deep learning objectives.

A comparative analysis of CBL and PBL across three dimensions-knowledge, learning paths, and competency cultivation-highlights their complementary value, as summarized in Table 1.

Table 1: Focus and Synergy of CBL and PBL

Dimension	CBL Emphasis	PBL Emphasis	Integrated Value
Knowledge	Real cases (e.g., repair orders)	Open problems (e.g., fault trees)	Contextualizes learning; drives depth
Learning Path	Inductive (case → theory)	Deductive (problem → solution)	Dual "practice-theory" cycles
Competency	Systematic analysis	Critical thinking	Enhances comprehensive problem-solving

An analysis of the core principles of CBL and PBL reveals that both methodologies share a strong outcome-oriented focus, aligning with the intrinsic demands of vocational education. Integrating these approaches can effectively address the urgent issues currently faced in fault diagnosis courses.

3. Constructing a CBL+PBL Integrated Teaching Model

3.1 Design Principles

The model is developed by fully considering the applicability of both pedagogies in automotive fault diagnosis courses, creating a dual-track collaborative system integrating enterprises and vocational institutions, while implementing a dual-loop teaching mechanism co-driven by CBL and PBL methodologies.

Enterprise-Institution Dual-Track Collaboration: Enterprise demands serve as the foundational pillar, with vocational institutions acting as the educational platform. Learning outcomes are evaluated through enterprise-led practical assessments, ensuring bidirectional interaction between industry and academia.

CBL+PBL Dual-Loop Mechanism:

Outer Loop (CBL-Driven): Authentic cases are used to guide contextualized case design, establishing a case library. CBL serves as the primary framework for real-world scenario immersion.

Inner Loop (PBL-Driven): A problem chain is generated to fuel inquiry-based learning. Through collaborative group problem-solving, students explore solution pathways and validate optimized strategies.

The dual tracks (enterprise-institution) and dual loops (CBL-PBL) interlink synergistically: problem chains are embedded within case analyses, and case-based evidence informs problem-solving processes, creating a cyclical teaching-learning feedback loop. The complete model architecture is visualized in Figure 1.

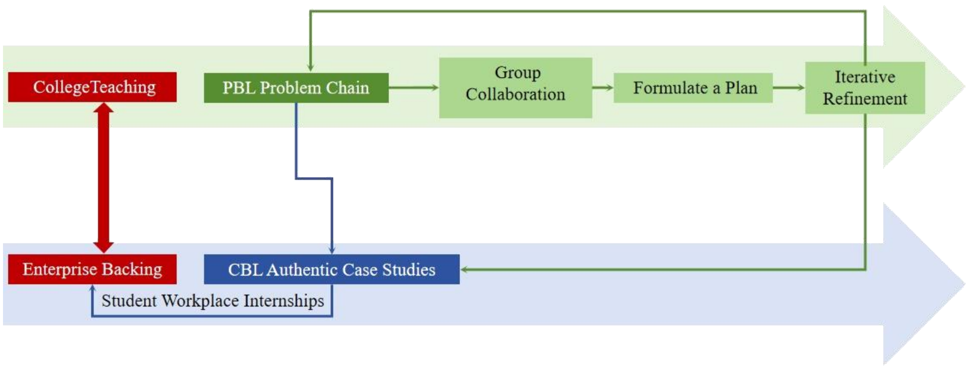

Figure 1: CBL+PBL teaching model

3.2 Teaching Model Design

(1) Case Scenario Outer Loop (CBL-Driven)

Based on real enterprise fault cases, authentic 4S are selected, including:

Fault manifestations (oil warning light on, blue smoke from exhaust pipe);

Historical maintenance records;

Dynamic data stream videos of the faulty vehicle, demonstrating abnormal parameters such as oil pressure and crankshaft ventilation valve.

(2) Problem Chain Inquiry Inner Loop (PBL-Driven)

Phase 1: Scaffolded Questioning

Progressive questions are raised based on the fault:

Entry-level question: How to verify whether the oil pressure sensor (triggering OBD-1 DTC

P0521 "Sensor Range Performance") is malfunctioning?

Advanced question: If the fault persists after sensor replacement, how to investigate mechanical factors (e.g., turbocharger seal integrity, piston ring wear)?

Phase 2: Role-Based Group Collaboration

Students adopt immersive roles (e.g., technician, engineer) to:

Analyze the fault through scenario-based simulations, forming direct perceptions of real-world issues.

Leverage interdisciplinary expertise to collaboratively develop solutions.

Systematically address teaching challenges through inquiry-driven exploration.

(3) Joint Industry-Academia Validation & Reflection

Academic practice: Use AR disassembly simulation software to validate fault resolution plans.

Industry linkage: Enterprise experts provide benchmark solutions. Students:

Compare their solutions with industry standards.

Collaboratively critique strengths/weaknesses of each approach.

Compile a fault diagnosis logic optimization report.

3.3 Teaching Case Development Phase

A core aspect of the integrated CBL+PBL teaching model involves collecting authentic fault cases. Through university-enterprise collaboration, a "three-tier case library"has been established, with its structure illustrated in Table 2.

Table 2: Three-Tier Case Library

Tier	Characteristics	Example
Basic	Single-system faults	Toyota Corolla ignition coil failure
Advanced	Cross-system faults	BYD Qin hybrid powertrain communication fault
Challenging	Complex/new-tech faults	Tesla Model 3 Autopilot radar calibration error

3.4 Multidimensional Evaluation System

To assess the attainment of teaching objectives, a "whole-process, longitudinal" evaluation model is established, with its construction methodology detailed in Table 3.

Table 3: "Whole-Process, Longitudinal" Evaluation Model

Dimension	Criteria	Weight
Process Evaluation	Task completion, team contribution	40%
Summative Evaluation	Diagnostic report quality	30%
Enterprise Evaluation	Tool use, 6S compliance	20%
Value-Added Evaluation	Innovative solutions	10%

4. Practical Outcomes

A controlled experiment (2023 cohort, 120 students) showed: Table 4. Results.

Table 4: Results

Metric	CBL+PBL Group	Control Group	Improvement
Diagnostic accuracy	87.4	62.1	+28%
Tool operation proficiency	92.3	75.6	+22%
Cross-system analysis	78.9	43.2	+82%

Experimental results demonstrate that the integrated CBL+PBL teaching model significantly enhances students' fault analysis capabilities and cross-system correlation analysis skills. Additionally:

Students in the experimental group won two first prizes in the "New Energy Vehicle Fault Diagnosis" category at the 2024 National Vocational College Skills Competition.

Enterprise feedback indicates that the average fault resolution time for interns from the experimental group decreased from 4.2 hours to 2.8 hours.

85% of students reported that the iterative workflow of "problem discussion → practical verification →post-action review and improvement" markedly strengthened their logical thinking abilities.

5. Conclusion

Through deep integration of CBL and PBL, three fundamental transformations are achieved:

(1) Knowledge Delivery: Shifted from fragmented knowledge rote memorization to systematic competency construction based on real-world workflows.

(2) Student Role: Transitioned from passive recipients to active problem solvers engaged in authentic diagnostic scenarios.

(3) Evaluation Framework: Evolved from single-outcome assessment to a multidimensional "competency + literacy" evaluation system.

This model effectively cultivates students' fault diagnostic expertise, inquiry-driven mindset, and collaborative problem-solving skills, providing a replicable framework for practice-oriented curriculum reform in automotive fault diagnosis courses at vocational institutions.

References

[1] Yao Haiyan, Li Xunzhang, Tan Qiuhong. Exploration of Problem-Driven Teaching Model[J]. Naval Petty Officer, 2023(01):26-27.

[2] Li Yanjuan. Exploration of High-Efficiency CBL+PBL Teaching Model for "Large-Scale Engineering Software" Courses[J]. Disciplinary Teaching and Talent Development Research, 2022(22):101-104.

[3] Yu Yan, Kang Guanghui. Task-Driven Multi-Platform Collaborative Online Teaching Design Integrating PBL-OBE[J]. Computer Education, 2023(07):176-180.

[4] Liang Xiaolin. Application of "PBL+TBL" Teaching Model in Instruction[J]. Office Automation, 2025(471):55-57.

[5] Zhang Qing, Yuan Rui, Zhang Yang, et al. Online Teaching of External Chinese Medicine Based on "Three Platforms + Three Dimensions"[J]. Observation and Reflection, 2023(754):57-59.