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

DOI: 10.23977/curtm.2025.080405
ISSN 2616-2261 Vol. 8 Num. 4

Application and Exploration of the CBL+PBL Teaching Model in Vehicle Fault Diagnosis Courses

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Keywords: CBL, PBL, Vehicle Fault Diagnosis, Teaching Model, Teaching Reform, Practical Ability

Abstract: This paper explores the application of the integrated CBL (Case-Based Learning) and PBL (Problem-Based Learning) teaching model in vehicle fault diagnosis courses. By analyzing the limitations of traditional teaching methods, the advantages and implementation strategies of the CBL+PBL model are elaborated. A teaching scheme based on this model was designed and applied in practice. The results demonstrate that the CBL+PBL model effectively enhances students' learning interest, problem-solving abilities, and practical skills, offering new insights for the teaching reform of vehicle fault diagnosis courses.

1. Introduction

With the rapid advancement of automotive technology, vehicle fault diagnosis courses play an increasingly vital role in cultivating high-quality automotive maintenance professionals. These courses are characterized by strong practicality and fast-paced knowledge updates. However, traditional teaching models often fail to meet the demands of modern vocational education due to disconnects between theory and practice, insufficient student engagement, and other issues[1]. The CBL+PBL teaching model, as an innovative pedagogical approach, integrates case-based and problem-oriented learning to enhance students' learning motivation, practical competencies, and problem-solving skills[1], providing a new direction for teaching reform in vehicle fault diagnosis. This paper aims to explore the application of the CBL+PBL model in this course, offering references for improving teaching quality and students' practical abilities.

2. Analysis of Current Teaching Status in Vehicle Fault Diagnosis Courses

Traditional vehicle fault diagnosis courses often adopt a "theory lecture+experimental verification" model. While systematic in knowledge delivery, this approach has significant shortcomings:

Firstly, Theory-practice disconnect, Students struggle to flexibly apply theoretical knowledge to real-world fault diagnosis;

Secondly, Students remain passive recipients, lacking initiative and problem-solving skills;

Finally, Monotonous methods, Uniform teaching content and methods fail to stimulate learning interest.

The CBL+PBL teaching model provides a novel approach to addressing these issues.CBL (Case-Based Learning) is a teaching method centered on real-world cases. By presenting specific case scenarios, it guides students to analyze, discuss, and solve problems, thereby enhancing their understanding and application of knowledge. PBL (Problem-Based Learning) is a student-centered approach that stimulates students' curiosity through practical problems, fostering self-directed learning and problem-solving skills.

The integration of CBL and PBL leverages the strengths of both methods. CBL provides authentic case scenarios as a practical foundation for PBL's problem-solving framework, while PBL motivates students to actively engage and creatively apply knowledge to deepen their understanding of cases.By authentic cases and practical problems, students' intellectual curiosity can be stimulated[2].Through analyzing cases and solving problems, they effectively integrate theory with practice,thereby enhancing their practical competencies.This combination not only boosts students' learning motivation but also cultivates their analytical and problem-solving abilities, making it particularly suitable for practice-oriented courses like vehicle fault diagnosis.

3. Instructional Design of the CBL+PBL Model in Vehicle Fault Diagnosis Courses

3.1. Setting of Teaching Objectives

3.1.1. Knowledge and Skill Objectives

Students should be able to systematically master the basic principles of vehicle fault diagnosis, common types of faults and their diagnostic methods. They should be proficient in using various diagnostic tools and equipment, and accurately analyze and solve actual vehicle fault problems.

3.1.2. Process and Method Objectives

Through the combination of CBL (Case-Based Learning) and PBL (Problem-Based Learning), students' abilities in problem analysis, teamwork, autonomous learning, and innovative thinking should be cultivated. They should be able to quickly formulate effective diagnostic strategies in complex fault situations.

3.1.3. Emotional Attitude and Value Objectives

Through scientific and reasonable teaching models and methods, stimulate students' interest in learning the field of vehicle fault diagnosis, enhance their sense of professional responsibility, and cultivate students' rigorous and scientific working attitude.

3.2. Analyze and integrate teaching content.

3.2.1. Screening of Typical Cases

Teachers should collect various real and representative vehicle fault cases, covering different vehicle models, fault types, and fault degrees. The sources of cases include actual maintenance records of auto repair shops, technical documents of automakers, and professional vehicle fault databases. Teachers need to classify and organize the cases according to the teaching progress and objectives of the course, such as engine faults, chassis faults, electrical system faults, etc.

3.2.2. Design of Problem Chains

For each case, design a series of inspiring and hierarchical questions around the key knowledge points and skill points of vehicle fault diagnosis. The problem chain should guide students to start from the fault phenomenon, gradually analyze the causes of the fault in depth, formulate a diagnostic plan, and finally solve the fault problem. For example, in the case of difficult engine starting, the problem chain can include: What are the specific manifestations of the fault phenomenon? What are the possible causes of difficult engine starting? How to use diagnostic tools for preliminary detection? How to further troubleshoot the fault?

3.3. Design of the Teaching Process

3.3.1. Case Introduction (10%)

The teacher presents the carefully selected vehicle fault cases to the students through multimedia display or on-site demonstration, guiding the students to observe the fault phenomena and describe the background and process of the fault occurrence. Teachers should stimulate students' curiosity and thirst for knowledge in this process, enabling them to quickly enter the learning state.

3.3.2. Problem Analysis and Discussion (30%)

Students conduct in-depth analysis and discussion of the fault problems in the cases in groups. The teacher distributes the designed problem chains to each group, guiding the students to carry out the discussion step by step according to the logical order of the questions. During the discussion, group members fully exchange their ideas and opinions, jointly analyze the causes of the faults, and put forward possible diagnostic plans[3]. The teacher patrols among each group, giving timely guidance and inspiration, and helping students solve the difficulties encountered during the discussion.

3.3.3. Autonomous Learning and Knowledge Construction (20%)

For the difficult problems encountered during the discussion, students conduct autonomous learning by consulting textbooks, reference materials, online searching, etc., to seek solutions. In the process of autonomous learning, students can not only obtain the knowledge needed to solve the problems but also cultivate their autonomous learning ability and information acquisition ability. The teacher encourages students to integrate the new knowledge obtained in the autonomous learning process with the existing knowledge system to construct a more complete knowledge structure[4].

3.3.4. Implementation and Verification of the Diagnostic Plan (30%)

Each group selects appropriate diagnostic tools and equipment according to the diagnostic plan obtained from the discussion and autonomous learning, and conducts actual detection and diagnosis of the faulty vehicle. During the implementation process, students operate in strict accordance with the operation procedures and record the detection data and the diagnostic process. After the diagnosis is completed, students verify the diagnostic results to determine whether the cause of the fault has been accurately judged. If the diagnostic results do not match the expectations, students need to re-analyze the problem, adjust the diagnostic plan until the fault problem is solved.

3.3.5. Summary and Evaluation (10%)

The teacher organizes the students to summarize the teaching activity, guiding the students to review the case analysis process and sort out the ideas and methods of vehicle fault diagnosis. Each group selects a representative to report on.

Throughout the process, teachers act as facilitators, encouraging active exploration and critical thinking.

4. Practical Application Case of the CBL+PBL Model in Vehicle Fault Diagnosis Courses

Taking the engine failure to start as an example, the four stages of the teaching model designed by CBL+PBL are shown in Table 1.

Table 1: The specific application of the teaching mode

Stage	Implementation Details
Case Presentation & Problem Construction	The instructor begins by introducing a real-world client case: A vehicle owner discovers their car fails to start in the morning, producing only a "clicking" sound during ignition attempts accompanied by flickering dashboard lights. Multimedia resources, including photos of the faulty vehicle, diagnostic trouble codes (e.g., crankshaft position sensor malfunction), and detailed symptom descriptions, are displayed to enhance authenticity. A simulated client interview further immerses students in the scenario. The instructor then poses the core question: "How to systematically diagnose and resolve this issue?" Students engage in group brainstorming, drawing on prior knowledge and experience to list potential causes, such as insufficient battery charge, starter solenoid failure, abnormal fuel pump pressure, ignition system faults, or ECU communication failures. This phase leverages Case-Based Learning (CBL) to spark interest and Problem-Based Learning (PBL) to drive critical thinking.
Theoretical Learning & Knowledge Integration	Following discussions, the instructor delivers structured lessons via micro-lectures and 3D animations, explaining the engine startup workflow across three systems: Mechanical System: Crankshaft-camshaft timing synchronization. Electrical System: Battery-starter-relay circuit interactions. Control System: ECU signal transmission mechanisms. Key technical details—such as the impact of missing crankshaft position sensor signals on ignition timing, battery internal resistance testing protocols, and fuel pressure standards—are emphasized. Students use mind maps to organize knowledge, identify subsystem interdependencies, and formulate diagnostic plans, for example: Step 1: Test battery voltage and internal resistance with a multimeter. Step 2: Retrieve ECU error codes via OBD-II scanners. Step 3: Measure fuel line pressure to assess pump functionality. Step 4: Inspect the starter solenoid's actuation force.
Practical Operation & Dynamic Adjustment	In the workshop, student groups execute diagnostic plans using tools like oscilloscopes, fuel pressure gauges, and circuit testers. While standardized procedures are provided, students adapt strategies based on real-time data. For instance: If battery voltage reads 11.8V (below the 12.6V standard), load testing determines replacement necessity; If fuel pressure is normal, focus shifts to ignition coils or crankshaft sensor signal waveforms. Students document test results, observations, and reasoning processes, updating fault tree analyses with fishbone diagrams. The instructor circulates among groups, posing reflective questions (e.g.,"Why wasn't the fuel system the root cause?") to address logical gaps and reinforce theory-practice integration.
Outcome Presentation & Multidimensional Evaluation	Groups present findings via PPT or live demonstrations, showcasing critical data, fault localization logic, and solutions (e.g., replacing the crankshaft sensor and reprogramming the ECU). A three-dimensional evaluation framework is applied: Technical Competence: Adherence to diagnostic protocols and tool accuracy. Logical Rigor: Clarity of analysis and elimination methodologies. Collaborative Skills: Teamwork efficiency and communication effectiveness.

	A simulated "client satisfaction" segment involves the instructor role-playing as the customer, challenging students on cost-effectiveness and repair timelines. Finally, common errors (e.g., overlooking ECU software resets) and variant cases (e.g., cold vs. hot start failures) are discussed to foster adaptive problem-solving.

Through this case, students acquire hard skills (e.g., battery testing, signal analysis) and develop systemic thinking, engineering decision-making, teamwork, and communication skills. The integration of CBL's concrete cases and PBL's inquiry-based learning embodies the "learning by doing" philosophy, fostering knowledge construction and competency transfer.

5. Conclusions

The CBL+PBL teaching model effectively resolves the shortcomings of traditional methods in vehicle fault diagnosis courses. By combining real cases and problem-driven learning, it significantly enhances students' practical engagement and problem-solving capabilities[5]. Practical results confirm its effectiveness in cultivating versatile talents aligned with modern automotive industry needs. Future research should explore integrating this model with virtual simulation technologies and industry-academia collaboration to further advance vocational education reform.

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