The Application of the PBL Group Collaborative Teaching Method Based on Scenario Construction in Vehicle Rescue Practical Teaching

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Abstract. Taking the vehicle repair and rescue course teaching of two cohorts of students majoring in vehicle repair and rescue as an example, the project-based learning (PBL) teaching method based on the vehicle rescue operation scenarios was applied in the practice teaching reform in aspects such as expanding the construction of practical teaching scenarios, formulating rescue plans, conducting practical teaching in scenarios, promoting group collaboration and implementing the course assessment and evaluation system. In the practical teaching of this course, the PBL collaborative group division teaching method based on scenario construction was mainly implemented. The application effect of team collaboration learning as the main approach in the practical teaching of vehicle rescue course under the background of multiple scenario construction and group collaboration was explored. The results show that this teaching method has improved students' examination scores and teaching quality to a certain extent, and enhanced students' comprehensive professional practical literacy.

Keywords: PBL teaching method, Teaching reform, Vehicle rescue, Practical teaching

1 Introduction

PBL (project-based learning) teaching method is a "student-centered, project-driven, group-based, aiming at cultivating students' abilities and qualities, and integrating knowledge acquisition and application in an inquiry-based learning model" [1]. This method differs from the problem-based teaching method (pbl) in that pbl starts and centers on problems, and learns knowledge and develops thinking through the process of solving problems. Instead, PBL mainly categorizes all problems within the scope of the project, drives the learning process through the completion of the project and the achievement of results/products, and is a more macro-level teaching approach. The PBL teaching method has undergone a gradual evolution and development process. Its theoretical prototype can be traced back to the early 20th century and has been improved and promoted through the practices of subsequent educators. The synergetics

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theory proposed by German physicist Harmann HaKen defines synergetics as "the science of coordinated cooperation" [2]. "Synergy" refers to the process or ability of coordinating two or more different resources or individuals to achieve a certain goal in unison, emphasizing that the combined effectiveness is greater than the individual functions [3]. Collaborative learning is an innovative design where learners participate in groups. Members of the same group have common learning goals and face common project challenges. Collaborative learning not only benefits the learners themselves but also others and the entire group [4].

The PBL teaching model originated earlier in foreign countries and has a wide influence. As early as the 1960s, Professor Barrows from McMaster University in Canada proposed the PBL teaching model. Initially, it was only widely applied in the field of Western medicine education [5]. Subsequently, the significant role of the PBL education model in the cultivation of learning skills and the transfer of knowledge was highly praised by the education community. American Peggy Ertmer summarized five key points of project-based learning: 1) Real-world learning, that is, proposing a real problem to drive the course; 2) Core to learning, emphasizing academic rigor, adding learning units, and emphasizing learning content; 3) Structured collaboration, that is, forming study groups to enhance teamwork; 4) Student-driven, that is, transforming the roles of teachers and students, with teachers becoming facilitators and students becoming active participants; 5) Multifaceted assessment, that is, incorporating assessment throughout the entire teaching process, emphasizing process assessment and students' self-assessment.

The implementation process of the PBL teaching model consists of six steps: project design and selection, plan formulation, activity exploration, work design, outcome exchange, and effect evaluation. The teacher assumes the roles of course organizer, learning guide, information consultant, and evaluation implementer. Through limited guidance of students' activities and providing them with evaluation feedback, the teacher conveys professional knowledge and skills, and organizes students to gradually complete each step of the PBL. Meanwhile, students act as autonomous learners, collaborators, and researchers. They need to support each other, discuss with each other, and conduct self-reflection, exerting their autonomy and initiative, and sharing responsibilities and obligations with their group members. As shown in Fig. 1.

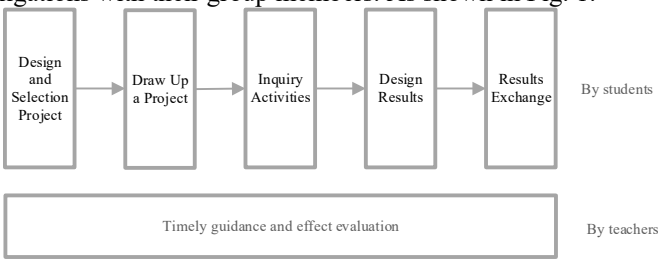

Fig. 1. The implementation process of the PBL teaching model

PBL has started relatively late in China, and most of it is still concentrated in the field of medical education [6]. Most of the discussions at home and abroad regarding the ap-

plication of PBL collaborative teaching methods in curriculum construction mainly focus on group discussions or operations driven by traditional problem-based approaches. However, when aiming at advanced production practices and scientific research projects and taking groups as the main body for comprehensive and diversified collaborative innovative learning, there is still a lack of substantial initiative.

Vehicle rescue refers to the collective term for self-rescue, towing, traction and evacuation operations carried out for vehicles that are submerged, damaged or have malfunctions. Generally, vehicle accidents usually include forms such as sinking, rollover and falling into ditches. For vehicles that still have usable value after the accident, other vehicles or professional rescue equipment can be used to rescue the damaged vehicle out of the trapped location while ensuring the safety of the passengers. The teaching content of vehicle rescue in domestic vocational education colleges has gradually developed along with the rapid development of the automotive industry, the sharp increase in vehicle ownership, the upgrading of rescue industry demands and the innovation of vocational education concepts. However, its development is far from complete. At the beginning of the 21st century, the relevant content and courses of vehicle rescue were mainly offered by military colleges and railway industry colleges based on special needs [7]. In ordinary colleges, it was only embedded as a knowledge module into traditional courses such as automotive application and maintenance, and transportation safety. Since 2010, due to the increasingly prominent traffic safety issues, society has clearly demanded professional and rapid vehicle accident rescue. Some vocational colleges and other educational institutions have begun to build the teaching and practical content of vehicle rescue as an independent teaching and practice direction. However, at present, there are problems such as insufficient specialized training resources, an incomplete systematic training mechanism, and a lack of standards for evaluating practical teaching effects [8]. Currently, there are almost no practical teaching models that can be referred to.

The vehicle rescue course is an important core course in the vehicle repair and rescue major. It mainly teaches the main methods and implementation processes of emergency handling and rescue escape for vehicles, and is a comprehensive application course for almost all professional courses in this major. It is highly applicable and practical. The quality of this course directly affects students' ability to engage in vehicle rescue work after graduation [9]. After years of teaching practice, a teaching model combining typical scenarios and typical operation methods, as well as individual skills and teamwork, has been summarized. However, in terms of the connotation and extension of the teaching content, the expansion is relatively limited, which to some extent restricts students' emergency handling capabilities. Therefore, in order to explore how to improve the practical teaching quality of the vehicle rescue course and reflect professional characteristics, in 2024 and 2025, students from classes 2201 and 2301 of the vehicle repair and rescue major were selected as research subjects to explore the implementation and application effect of the diversified collaborative innovation practical teaching model based on PBL constructed on the basis of actual application scenarios and organized in the form of student learning groups in the vehicle rescue course. This can provide a reference for the construction of similar professional courses in vocational colleges.

2 The Application of the PBL Group Collaboration Teaching Method in the Vehicle Rescue Course

2.1 Establish a Practical Teaching Content System Based on Scenario-Based Training

To achieve a high degree of alignment between the teaching of vehicle rescue courses and practical application requirements, in recent years, the professional teaching team has actively explored and established a practical teaching content system centered on scenario-based training. Scenario construction forms the basis of our project-based learning instructional design. The development, verification, and implementation of these scenarios follow a rigorous process to ensure their relevance, authenticity, and educational value.

- Scenario Design: The scenarios mainly come from two sources: a) analysis of real vehicle rescue case reports provided by partner organizations; b) interviews with experienced rescue professionals to determine common challenges and key decision points. Each scenario is designed with specific learning objectives, detailed environmental conditions (such as night, rain, rough terrain), vehicle conditions (such as emergency situations, damage level, location), rescue equipment, tools and materials, and clear task requirements. When necessary, the assistance of a generative large model can be used to make the scenario construction more detailed and specific.
- Scenario Verification: The initial scenarios are reviewed by a team consisting of at least two senior teachers of the vehicle rescue course and an external industry expert. This team will assess whether the scenarios meet the learning objectives, the feasibility of operation in the training site, and potential safety risks. Based on the feedback received, the scenarios will be continuously optimized.
- Scenario Implementation: A typical example is "Night rescue after a vehicle rollover on a gravel road in the mountains". The scenario is set as follows: at 22:00, in rainy weather, a vehicle rolls over on a remote gravel road, and a passenger is trapped inside. The vehicle is unstable and there is a risk of fuel leakage. The student groups will receive a set of standard rescue tools and must develop a plan covering scenario assessment, vehicle stabilization, safe rescue of the passenger, and management of potential dangers. This scenario effectively integrates the application of knowledge such as mechanics, vehicle structural stability, and teamwork under pressure. Such specific examples ensure the repeatability of our teaching practice.

2.2 Conduct PBL Teaching Through Group Collaboration

- Centered on the vehicle rescue scenario, design and select the project. The project, as the core of PBL teaching, runs through the entire teaching process from beginning to end and is the focus of attention for both teachers and students. Professional teachers design rescue projects with practical significance before teaching, such as "rescue of vehicles stuck in swamps" or "quick handling of overturned vehicles in mountain-

ous areas". They also add details about weather and terrain. During the class, students form collaborative groups, usually consisting of 5 people. The groups choose the project through collective discussion. Once the groups have selected the project, the classroom announces the details and task requirements of the project to each group.

- As a basic unit, the group collaborates to formulate the plan. Under the guidance of the teacher, the group members jointly study and formulate a detailed rescue plan, including: task background, scene characteristics, rescue requirements, time schedule, personnel division, resource list, etc. Students in the same group can organize meetings or use online platforms for communication after class to ensure clear task division. At the same time, they jointly conduct task risk assessment and safety plan formulation, and set milestones.
- Through real-site training and group collaboration, conduct learning exploration. In the training site, the group is responsible for creating simulated training scenarios, such as vehicle rollover or mudslide scenes. After the scenarios are set up, exploration activities are carried out. Collect basic data of the scene (such as the degree of vehicle damage, terrain data), formulate rescue plans, clarify operation divisions, select rescue equipment and materials, determine rescue implementation steps, and conduct role-playing practical training based on this. The professional teacher acts as a consultant and can provide limited guidance on-site, mainly focusing on grasping key points, standardizing operation procedures, and ensuring operation safety. Group members solve problems through collaborative training and determine the optimal rescue plan.
- Summarize the rescue plan and results, complete the project design. Based on the results of inquiry learning and practical operation, the group summarizes and generalizes the specific achievements of the project, such as "vehicle rescue operation plan" (including flowchart, equipment list) or simulated rescue demonstration. Encourage students to organize their knowledge system through effective independent learning and collaborative learning and to comprehensively apply them, demonstrating the core knowledge and skills of this course. During the summarization process, student groups integrate relevant knowledge and skills, while the teacher provides individual guidance to help each group correct errors and refine the core skill points.
- Organize project presentation and exchange of experiences and insights. Each group showcases their project outcomes through a centralized presentation activity. For instance, they conduct a live demonstration of the rescue process at the training site, with 1-2 members explaining the plan, while the rest operate the equipment and answer questions. Groups can also evaluate the feasibility of the plans with each other to improve the quality of the work. The teacher uses this link to conduct formative assessment, providing immediate feedback on the identified issues and strengthening students' enthusiasm for self-study in a targeted manner.
- Through diversified assessment and feedback, achieve effect evaluation. The evaluation of each group's project completion is composed of teacher's comments, students' self-evaluations, and group mutual evaluations. The focus is on examining the quality of the group's full-process project practice in the given rescue scenario: including the rationality of the plan, the degree of plan execution, the flexibility of

skills, the achievement of safety, the coordination of the team, and so on. At the same time, through group reflection meetings, a "teaching - training - assessment - feedback" closed loop is established. The teacher summarizes the data for course improvement to ensure the continuous optimization of PBL teaching. we have explicitly mapped the learning outcomes to specific evaluation criteria. The following table illustrates how each teaching reform objective is aligned with its corresponding assessment method and indicator, ensuring that the evaluation directly reflects the achievement of the intended learning goals. As shown in Table 1. This explicit mapping ensures that the assessment system is tightly coupled with the teaching objectives, enhancing the validity and clarity of our evaluation approach.

Table 1. Alignment of Teaching Objectives and Assessment Indicators

Teaching Reform Objective	Intended Learning Outcome	Assessment Method & Indicator
Enhance collaborative problem-solving skills	Students can collaboratively develop a scientifically sound and operable rescue plan.	**Plan Evaluation (Group Score):** Assessed by instructors using a rubric (0-5 points) focusing on plan completeness, feasibility, and division of labor rationality.
Improve practical operation competence	Students can proficiently use tools and execute rescue procedures according to the plan.	**On-site Operation (Individual Score):** Assessed by instructors using a checklist (0-5 points) focusing on procedure standardization, tool usage, and safety compliance.
Cultivate innovative thinking & adaptability	Students can propose alternative solutions or adapt effectively to unexpected situations in the scenario.	**Performance in Scenario Simulation (Group & Individual Score):** Assessed through instructor observation and post-scenario reflection reports, focusing on flexibility and innovation (0-3 points).
Strengthen integration of theoretical knowledge	Students can correctly apply theoretical knowledge (e.g., mechanics, vehicle structure) to analyze and solve problems during the rescue process.	**Final Comprehensive Report (Individual Score):** Evaluates the depth of theoretical application and analytical reasoning in the written report (0-4 points).

2.3 Multi-dimensional Collaborative Reform of the Curriculum Evaluation System

Establish an evaluation system mainly consisting of formative assessment, summative assessment, and comprehensive practical activity assessment, and a full-chain multi-dimensional vehicle rescue course practical teaching quality evaluation system with teachers' evaluation, students' evaluation, and employers' evaluation as the main bodies. Achieve the full-process and full-field monitoring of practical teaching quality. Implement quality awareness, quality standards, quality evaluation, and quality management in all aspects of vehicle rescue course practical teaching.

3 Effectiveness Evaluation

This study selected two classes from the Vehicle Maintenance and Rescue major. Class 2301 (n=36) adopted the PBL group collaboration teaching method as the experimental class, while Class 2201 (n=35) used the traditional scenario-based teaching method as the control class. In the traditional method, the teacher first demonstrated the standard rescue plan and procedures, and then the students practiced in the scenarios. To ensure baseline equivalence and assess the representativeness of the sample, detailed personal and academic background information was collected and summarized in Table 2. Independent sample t-tests and chi-square tests indicated that before the intervention, there were no statistically significant differences between the two groups in terms of age, gender distribution, and examination scores of related basic courses (such as mechanical fundamentals) ($P>0.05$). Additionally, both classes used the same teaching staff, textbooks, and practical venues, thereby controlling for potential confounding variables.

Table 2. Baseline Characteristics of the Experimental and Control Classes

Characteristic	Experimental Class (n=36)	Control Class (n=35)	P-value
Age (years, Mean ± SD)	19.5 ± 0.8	19.6 ± 0.7	0.55
Gender (Male/Female)	34 / 2	33 / 2	0.94
Entrance Score - Automotive Fundamentals (Mean ± SD)	82.3 ± 5.1	81.9 ± 4.8	0.72
Entrance Score - Mathematics (Mean ± SD)	78.5 ± 6.2	77.8 ± 5.9	0.61

3.1 Comparison of Grades of Two Classes

The comprehensive practical performance includes formative assessment scores (40%) and final assessment scores (60%). The formative assessment scores are evaluated by

the teaching team based on the students' actual performance during the internship, including individual skills (30%) + teamwork (35%) + practical effect (45%). The scoring criteria for the experimental report: including assessment preparation (5%) + rationality and standardization of the assignment method (60%) + assessment effect (35%). By comparing the comprehensive practical performance, the grades of the experimental class were generally higher than those of the control class (Fig. 2). The reform of the course has enhanced students' enthusiasm and interest in the course, enabling them to exert their initiative and actively engage in practice, asking questions when they don't understand. Among them, the number of students with formative assessment scores ranging from 90 to 100 increased to 8, and the number of students with scores ranging from 80 to 89 increased to 15. The excellent rate of final assessment scores also significantly increased.

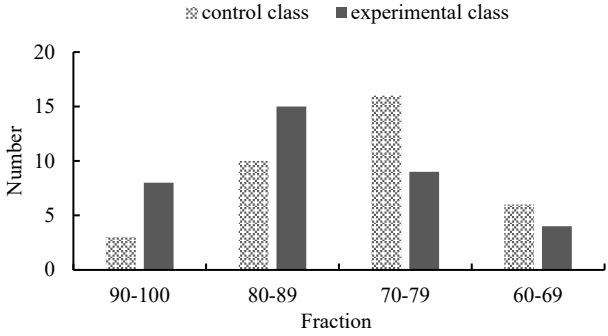

Fig. 2. Score distribution of practical performance

3.2 Student Satisfaction Questionnaire Survey

A satisfaction questionnaire survey was conducted on the teaching effectiveness of two classes that implemented different teaching methods (Fig. 3). The survey content included whether the students were satisfied with the positive effects of the two teaching methods on teaching outcomes, communication skills, collaboration skills, self-study ability, practical operation ability, and understanding and mastery of theoretical knowledge; and whether they liked the teaching methods applied in their respective classes. A total of 71 questionnaires were distributed among the students of the two classes, and 71 questionnaires were returned, with an effective return rate of 100%. The feedback results are as follows: The very satisfaction rate reached 62% (38% from the experimental class and 24% from the control class), the comparative satisfaction rate reached 34% (21% from the experimental class and 13% from the control class), 4% was considered average (all from the control class), and 0% was dissatisfaction. Relatively speaking, the students in the experimental class showed a higher recognition of the reform-based teaching methods and their teaching effects than those in the control class who recognized the traditional teaching methods.

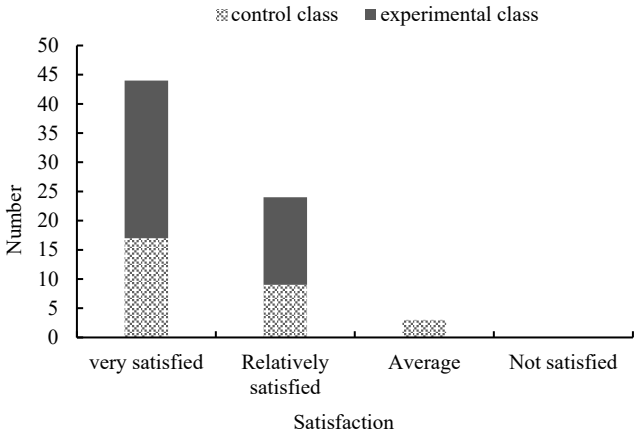

Fig. 3. Reformed teaching satisfaction comparison

3.3 Teacher and Student Counselor Satisfaction Questionnaire Survey

Questionnaires assessing the practical ability of students (Table 3) were distributed to the teachers who conducted the graduation assessment of two teaching classes (excluding the teachers of the vehicle rescue course), as well as the student counselors. In the questionnaire, "Yes" or "No" indicated the respondents' evaluation of the students' performance. From the evaluation forms, it can be seen that after the reform of the course, the practical operation ability of students has generally improved. The reform of the practical teaching in the course has gradually strengthened the students' awareness of cooperating and collaborating with each other. During the internship, students can jointly analyze and handle problems, which has enhanced their teamwork awareness and ability.

Table 3. Teacher and student counselor satisfaction survey

Project	**Experimental class (n = 36)**		**Control class (n = 35)**	
	Yes	*No*	*Yes*	*No*
Good practice effect	26	10	22	13
strong self-learning ability	23	13	19	16
High concentration ability	26	10	22	13
skillful operation	24	12	20	15
Team spirit	27	9	21	14

Strong ability in applying knowledge	24	12	19	16
Excellent in people communication	28	8	23	12

The effectiveness of the PBL approach was evaluated by comparing the outcomes between the experimental class (PBL) and the control class (traditional teaching method), which provides stronger evidence for causal inference than a simple pre-post comparison. As shown in Fig. 2 and Table 1, the experimental class demonstrated superior performance in comprehensive practical scores and received higher recognition in various competencies from teachers and counselors.

4 Discussion and Conclusion

Compared with the control class, the experimental class demonstrated significant progress under the same baseline conditions. This strongly indicates that the PBL teaching intervention was the main factor contributing to the improvement in learning outcomes, rather than general learning progress or other external variables. This student-centered practical teaching model, where the teacher acts as a helper and facilitator for students' learning, provides favorable conditions for students' autonomous learning and cultivates their technical literacy and innovative thinking. It effectively enhances students' self-study ability and innovation ability. Through practical assessment, students pay more attention to the cultivation of innovation, collaboration and practical abilities, ensuring their all-round development. By comparing the learning situations of the experimental class and the control class, it was found that the teaching effect, course scores, collaborative spirit and positive responses of the students in the experimental group were all higher than those in the control group. This indicates that the PBL teaching method based on scenario-based teaching and mainly focusing on team collaboration learning is more effective than the traditional teaching method. This method is necessary to be promoted in vehicle rescue and similar practical course teaching.

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