Investigation and Practice of PBL Method in Organic Chemistry Laboratory Teaching in the Context of Internet+

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Abstract. In response to the demands of organic chemistry laboratory teaching in the context of Internet+, this study explores the application of problem-based learning (PBL) in this field. Building upon the foundation of a web-assisted teaching platform, a student-driven inquiry-based experimental teaching model was designed. Taking the development of preservatives as an example, project-based learning was employed to cultivate students' practical and innovative abilities. Compared to traditional teaching methods, this model demonstrates significant advantages in stimulating active learning and fostering transferable skills. The distinctive feature of this research lies in its integration of problem-based learning concepts, web technology, and specific application scenarios, providing a comprehensive teaching reform solution from theory to practice that can be a valuable reference for similar explorations. Additionally, it has established a measurable model in aspects of teaching process evaluation, achieving a balance between quality and quantity. This study has constructed an organic chemistry laboratory teaching model based on problem-based learning principles in the Internet+ era, offering valuable insights for classroom teaching reforms in the new era.

Keywords: PBL teaching method; organic chemistry experiments; online teaching

1 Introduction

Organic chemistry laboratory teaching is a critical component in nurturing applied talents; however, it has long been dominated by verification experiments, lacking in the cultivation of students' practical skills and innovative thinking. To meet the demands of new developments, it is imperative to establish a new experimental teaching model adapted to the Internet+ era. This paper, in the context of this background, explores a web-assisted experimental teaching approach based on problem-based learning (PBL) principles. By utilizing information technology, we expand the boundaries of teaching and learning, create an online platform, design open-ended experimental projects, and introduce teaching organizational forms such as theoretical connections, situational experiences, and autonomous inquiry, resulting in a complete reform plan [1]. The research indicates that this teaching model can effectively stimulate learning interest and cultivate students' transferable skills. The significance of this paper lies in providing a theoretical and practical reform framework for laboratory teaching in the new era of science and engineering. Subsequent work will further enrich the functionality of the online platform, improve the hybrid teaching evaluation system, and promote this model to more institutions.

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2 Organic Chemistry experiment teaching model based on problem-oriented learning under Internet + conditions

2.1 Main characteristics of problem-based learning teaching method

Problem-based learning (PBL) emphasizes a student-centered teaching philosophy, aiming to cultivate critical thinking and independent learning skills by enabling students to actively analyze and solve complex real-world problems. The PBL teaching method has three main characteristics: First, problem-driven. In PBL teaching, learning starts with complex real-world problems or scenarios. Teachers initially design a challenging problem situation that aligns with the subject matter and is structurally complex, sparking students' motivation and needs for learning. For example, in organic chemistry experiments, an experiment topic could be to detect the preservative content in food and pharmaceuticals, making it more relevant to real-life situations. Second, student autonomy. Under the guidance of teachers, students are required to independently analyze the problem situation, identify their own knowledge limitations, and then explore knowledge through various means to construct problem-solving approaches [2]. Teachers play a more guiding, coordinating, and assisting role. In organic chemistry experiments, students can independently consult literature and design experimental plans. Third, group collaboration. PBL teaching emphasizes cooperation among students, typically forming small groups of 3-8 members. Group members collaborate, delegate tasks, supervise each other, share knowledge, and transmit experiences, effectively addressing complex problems.

2.2 Design of problem-based learning teaching model for organic chemistry experiments based on network platform

Internet technology provides an effective avenue for the application of PBL teaching methods. In this study, we developed a PBL model to assist organic chemistry laboratory teaching on a MOOC platform, with specific design details.This model comprises three modules: the Problem Scenario module, the Online Resources module, and the Teaching Activities module. The Problem Scenario module provides complex experimental research projects, the Online Resources module includes videos, documents, tools, etc., to support independent learning, and the Teaching Activities module revolves around group discussions and teacher guidance. In the actual implementation, teachers initially upload organic chemistry experimental research projects, such as the development of new preservative products. Students log in to the platform, independently study relevant knowledge, engage in online discussions, and draft experimental plans. Subsequently, students conduct experimental research in the laboratory and input experimental data into the platform repository. Teachers can track students' learning progress and effectiveness in real-time, providing guidance and suggestions. The entire process fully demonstrates the supportive role of the web platform in PBL teaching [3].

3 Experimental Teaching Platform Function Design and Implementation

3.1 Overall Platform Framework Design

The web-assisted organic chemistry laboratory teaching platform developed in this study consists of three levels: the User Level, the Function Level, and the Data Level, with the structural design shown in Figure 1. At the User Level, it supports access for multiple roles, including students and teachers. The Function Level encompasses modules for learning and communication, teaching management, and system maintenance. The Data Level integrates experimental data, teaching resources, user data, and more.

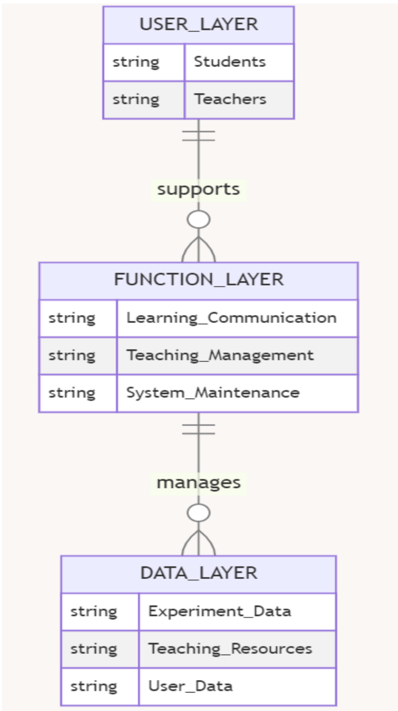

Figure 1: Overall Framework Diagram of the Web-Assisted Experimental Teaching Platform

In the specific system development, we adhere to a lightweight design philosophy. The server-side of the platform is built using open-source PHP language and MySQL database, ensuring low cost and high security. The client-side supports access through both web pages and mobile apps, facilitating multi-device usage [4]. This holistic design enables resource sharing and efficient management, effectively assisting experimental teaching.

3.2 Detailed Design of the Platform's Key Functions

The main functional modules of the web-assisted experimental teaching platform include experiment project management, organization of teaching resources, tracking of the teaching process, academic assessment, and feedback. These modules support the entire teaching process, as detailed in Table 1.

Table 1: Main Functional Structure of the Platform

Functional Module	Main Responsibilities
Experiment Project Management	Publish experiment project topics; Organize project groups.
Organization of Teaching Resources	Add teaching documents, videos; Maintain a resource link library.
Process Tracking and Communication	Report learning progress online; Community question and discussion forum.
Academic Assessment and Feedback	Testing and assessment; Survey questionnaire completion.

The various modules work in coordination, ensuring both the standardization of teaching by instructors and the promotion of student engagement, thus achieving effective assistance of the web platform in organic chemistry laboratory teaching[5].

3.3 Implementation of platform functions

The core functions of the network assisted experimental teaching platform are experimental project management, teaching resource organization, process tracking and communication, etc. The realization of these functions is based on the platform software system. The system consists of user interface layer, function realization layer and data management layer. At the user interface level, responsive Web page design is adopted to realize the personalized design of different roles of students and teachers. On the server side of the platform, LAMP technology stack (Linux+Apache+MySQL+PHP) is used to realize various functions through PHP language and persistent storage of MySQL database (see Table 1). In the experimental resource management module, we use semantic network technology to automatically classify and organize resource links by extracting working verbs and other elements of experimental documents, so as to effectively improve retrieval efficiency. In terms of process monitoring, the system uses online reporting and Data API to achieve data collection and analysis, forming a "number evidence chain" of students' experimental research behavior and providing a basis for teaching evaluation[6]. The test shows that the coupling degree between the functional modules of the platform is low and the flexibility is high. Under the condition of 100Mb bandwidth and 50 concurrent users, the functional response time is about 1.5 seconds, which can meet the needs of teaching use (see Figure 2). This proves that the platform software system design is reasonable and can support the experimental teaching application.

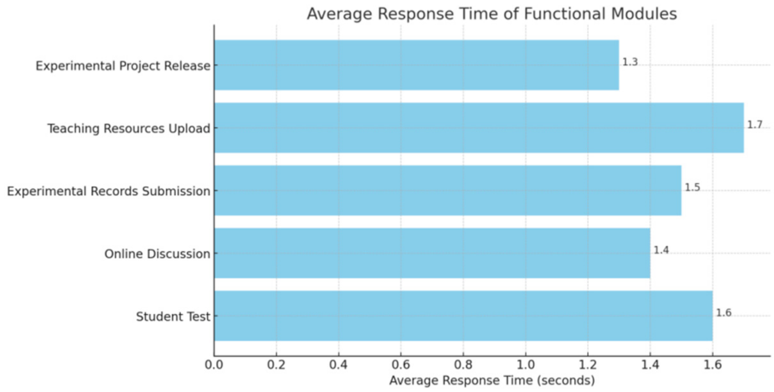

Figure 2: Platform Function Response Time

4 Teaching Experiment Design and Process Assessment

4.1 Design of Organic Chemistry Experiment Cases

In this study, we leveraged the online platform to design an organic chemistry experiment project with the theme of developing preservative products. This project consists of two phases: organic synthesis experiments and product testing. Students are required to apply their acquired knowledge to design experimental plans for synthesizing preservatives, choose suitable reaction conditions, and record experimental data. They also use methods like UV spectrophotometry to test the preservative's effectiveness, ultimately completing the development of preservative products [7]. In the actual teaching process, 20 students were divided into four groups, with five members in each group. They engaged in multiple rounds of discussions and revisions on the project proposal on the platform and collaborated to complete the experiments. The teacher provided guiding advice on each group's proposal and technical approach. The students conducted two weeks of experimental research and entered 60 sets of experimental records into the platform's database.

4.2 Problem-based learning teaching implementation process and effect evaluation index system

To evaluate the actual effectiveness of PBL teaching in organic chemistry experiments based on the online platform, this study constructed a process assessment and effectiveness evaluation system. The main indicators include:1)Experiment Design Evaluation: Assessing the scientific and innovative aspects of students' submitted experimental design proposals.2)Experimental Skills Assessment: Examining students' basic experimental operations and data processing abilities.3)Learning Attitude Evaluation: Assessing students' proactivity, cooperativeness, and learning attitudes.4)Academic Performance Evaluation: Testing students' mastery of knowledge points [8].The evaluation of each indicator is conducted through quantitative scoring or questionnaire surveys, and an overall evaluation model is constructed, as shown in Formula 1:

$$Y = \omega_1 X_1 + \omega_2 X_2 + \omega_3 X_3 + \omega_4 X_4 \quad (1)$$

Where Y represents the overall effectiveness, X_i represents each assessment indicator, and $\omega_i$represents the weight. This evaluation system comprehensively examines the practical application of the PBL teaching model.

5 Conclusion

A new organic chemistry laboratory teaching model based on the problem-based learning (PBL) concept and supported by a web platform is an important exploration in current teaching reforms. This study has created a web-assisted PBL experimental teaching platform with rich teaching resources, process tracking, and academic assessment features. Additionally, in combination with the application and development of organic chemistry knowledge, a PBL teaching practice was designed with the theme of developing preservative products. In project-based learning, students' experimental skills and critical thinking abilities have improved, achieving good teaching results. This research not only provides valuable ideas and practical paths for science and engineering laboratory teaching but also accumulates extensive data and cases from frontline teaching practices, especially addressing the lack of research on PBL in web-assisted organic chemistry laboratory teaching [9-10]. Furthermore, it suggests the need for continuous improvement in blended online and offline teaching and the establishment of a more comprehensive evaluation system and methods. In summary, PBL teaching, as a new paradigm for experimental teaching, is worth further promotion and implementation.

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