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Effect of Project-Based Blended Learning(PJBBL) on Algorithm Design and Analysis Ability

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ABSTRACT:

To improve the algorithm design and analysis abilities of computer students, it was necessary to enhance traditional learning models. By studying students' needs for project-based blended learning(PJBBL) models, a 5-dimensional student needs questionnaire was designed, and a PJBBL model was developed based on the analysis of student needs. Firstly, 100 students were randomly selected for a student needs questionnaire survey. From the survey results, it was found that the mean value of each dimension was greater than 4, indicating that students had a strong willingness to participate in the learning of the PJBBL model in algorithm design and analysis courses. Secondly, based on the requirements results, a PJBBL model was developed, which was divided into six parts: build project, scenario construction, divisions of student roles, project plan, project implementation, and project evaluation and improvement. Finally, an experimental group consisting of 36 students and a control group consisting of 33 students were used for course learning using PJBBL and traditional learning models, respectively. After completing the course, the algorithm design and analysis abilities of two groups of students were assessed using achievement to obtain test scores. After t-test analysis, it was observed that the mean value of the experimental group was 72.73, while the mean value of the control group was 64.17, and the significance value (sig) was 0.003, which was less than 0.05. Therefore, it was statistically confirmed that the PJBBL model significantly improved students' algorithm design and analysis abilities.

Keywords *Students' Needs, Algorithm Design and Analysis Abilities, Project-Based Blended Learning(PJBBL)*

1. INTRODUCTION

The rapid development of information technology and the arrival of the AI era have necessitated a significant demand for computer talent in society. According to the U.S. Bureau of Labor Statistics (2020), it was estimated that from 2019 to 2029, the employment of computer and information technology professions increased by 11%, significantly surpassing the average growth rate for all professions. A report by McKinsey & Company estimated that China would require approximately 700,000 to 900,000 new IT professionals annually in the coming years to meet growing demand (Woetzel et al., 2014). Especially with the advent of the AI era, high-quality computer engineers are needed to develop and maintain intelligent software and devices, and higher education institutions were tasked with cultivating high-tech computer engineering talents. Computer related majors, including computer science and technology, software engineering, network engineering, etc., are basically engineering majors. Engineering majors prepare students to primarily pursue careers in engineering development or management positions after graduation (Mata & Tob, 2018). These graduates are expected to quickly secure relevant employment opportunities upon completing their courses.

Algorithm design and analysis ability is an essential quality that computer science students should acquire. Proficiency in programming and algorithms can enhance students' logical thinking abilities, as programming demands strong logical and abstract skills. Through hands-on programming practice, students can exercise their cognitive abilities, ultimately leading to improvements in logical thinking, problem analysis, and creative thinking skills (Haryadi et al., 2021). These skills were typically developed through courses on algorithm design and analysis. However, these courses often covered a broad spectrum of content, resulting in a somewhat fragmented approach to teaching. Traditional teaching methods focused on imparting the mathematical and logical foundations of specific algorithms individually, often employing a particular programming language for implementation and testing (Wu, Xu & Zhou, 2022). Additionally, students entered these courses with varying levels of mathematical and physics backgrounds. Traditional curriculum delivery placed significant emphasis on grasping the fundamentals of mathematics and physics, often lacking engaging real-world application examples. This lack of practical context could diminish students' enthusiasm for learning, make the process less engaging, and increase feelings of frustration. Consequently, it deterred students from fully engaging with the course and hindered their ability to

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develop a comprehensive set of professional skills. This, in turn, eroded their competitiveness and confidence in future job opportunities (Xu et al,, 2021).
Therefore, through research and analysis of the needs of both students, the course's teaching content can be redesigned to align with project-based learning principles, while the integration of blended learning can enhance students' learning efficiency. This approach will ultimately enable students to better master their algorithm design and analysis abilities.

2. RESEARCH QUESTIONS

(1) What were the student' needs for PJBBL?
(2) How to develop PJBBL in algorithm design and analysis course?
(3) Whether PJBBL model significantly improve algorithm design and analysis ability of compared with traditional teaching methods?

5. OBJECTIVES OF THE RESEARCH

(1) To study student' needs on PJBBL.
(2) To develop PJBBL in algorithm design and analysis course.
(3) To study the effect of PJBBL on algorithm design and analysis ability.

3. LITERATURE REVIEW Overview of students' needs

Hutchinson and Waters (1987) classified requirements into target requirements, including the knowledge learners need to master when using a language in different environments, which were divided into needs, deficiencies, and wants. Learning needs refer to the objective and subjective things that need to be done to achieve learning goals, such as the learning environment, conditions, learners' knowledge and skills, and motivation. However, the research on demand theory has some limitations, and it is necessary to further explore and analyze the requirements of learners in different fields. Needs analysis, a methodology for researching needs through introspection, interviews, observation, and questionnaires during curriculum design and implementation, was first proposed in the 1970s for English for Special Purposes (Brown, 1995). Today, it is widely used in various fields such as education, finance, trade, and services. For example, Huang (2020) designed a Chinese language learning needs questionnaire for Chinese employees based on Hutchinson and Waters' needs analysis model and conducted a survey to identify their language learning needs. Similarly, Wu (2022) used a questionnaire to collect information on the basic information, target needs, learning needs, and motivation of respondents, including their focus of learning, duration of learning, and learning information needs. Liu (2022) investigated the needs of Chinese learners in terms of learning environment and learning process by designing a mixed learning needs questionnaire based on MOOCs. The study analyzed the impact of gender, Chinese language proficiency and learning type on the learning process and environment needs of Chinese learners.
In summary, this study draws upon previous research methods related to learning needs, addressing the challenges in traditional learning, the development of algorithm design and analysis abilities, and the expectations for new learning modes. It involves separate analyses of students' needs.

Overview of Algorithm Design and Analysis Ability

Algorithm design and analysis ability pertains to the capability to choose appropriate algorithms for designing, optimizing, and analyzing solutions to problems. It stands as a crucial skill in disciplines like computer science and informatics, encompassing knowledge of algorithms, algorithm design, algorithm optimization, algorithm analysis, programming implementation, and more (Tang, 2020).
Anwar et al. (2022) believed that engineering education played a crucial role in providing high-quality training for graduates to address the challenges posed by the COVID-19 pandemic and its aftermath. This assertion holds true for electronic engineering education as well. The research method employed in the application of hybrid learning projects in electronic engineering education courses involved project-based product design and development through hybrid learning.
Naragund & Handur (2013) posited that algorithms constituted the backbone of computer science and engineering, allowing computers to efficiently accomplish tasks. Courses on algorithm design and analysis were designed to cultivate students' problem-solving skills, provide them with effective design strategies, and enable them to evaluate algorithm performance.
Wang et al. (2020) argued that algorithm design and analysis courses facilitated students in comprehending the theoretical complexities of algorithms, acquiring proficiency in calculating temporal and spatial complexities, and solving real-world problems. In pursuit of these goals, they advocated for a discussion-based teaching model that

underscored the active participation of students in the learning process and clarified the role of teachers in guiding instruction.

In summary, the aspects related to training and evaluating algorithm design and analysis abilities have been reasonably well-defined, and various instructional methods have been explored. In this study, the primary approach involves integrating blended learning and project-based learning, utilizing diverse teaching software to enhance students' algorithm design and analysis ability further.

Overview of Project-Based Blended Learning (PJBBL)

Project-Based Blended Learning is a teaching approach that integrates project-based learning and blended learning methods. It enables students to learn and develop skills through a combination of hands-on project work and online learning. This approach typically includes elements such as design projects, online learning components, practical projects, as well as reflection and summary steps (Kirschner, 2006).

In educational technology, researchers have investigated the effectiveness of project-based learning in a blended learning environment on students' learning experience and outcomes (Chiang & Lee, 2016). To enhance the online practice of project-based learning, some researchers have incorporated technologies such as virtual laboratories and online collaboration tools (Klentien & Wannasawade, 2016).

Cognitive psychology researchers have examined student learning strategies, self-regulation abilities and overall learning effectiveness in project-based learning within a blended learning context (Pohan & Maulina, 2022). It was found that project-based learning based on blended learning promoted the development of student self-regulation and collaborative abilities, leading to improved learning outcomes (Yilmaz et al., 2020).

In summary, project-based learning based on blended learning was widely researched, particularly during the COVID-19 pandemic. However, several unresolved issues required further exploration. Firstly, how to synchronize online and offline implementation at every stage of the project to effectively integrate project-based teaching with blended learning was a key concern. Secondly, online teaching did not only focus on traditional content delivery but also incorporated activities such as autonomous learning, research, and team organization.

4. CONCEPTUAL FRAMEWORK

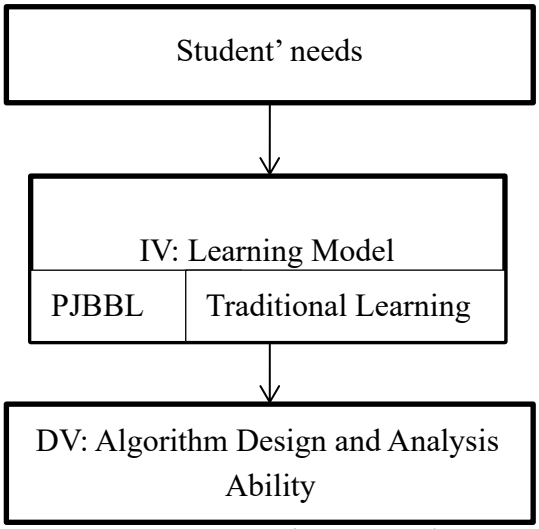

Figure 1 Research Framework

6. RESEARCH METHODOLOGY Research Process

Phase 1: study student' needs
Phase 2: develop PJBBL model
Phase 2: study effects of PJBBL on algorithm design and analysis ability

Population and Sample

a. Population and sample of student' needs:

Select 100 students from 163 students to participate in the needs survey using simple random sampling. b. Population and sample of study effects of PJBBL on algorithm design and analysis ability:

Two classes were selected from four classes using the cluster sampling method. One class constituted the experimental group, consisting of 36 students, while the other class comprised the control group, consisting of 33 students.

Research Instruments

(1) Questionnaire, IOC and reliability testing

(2) Project-based blended learning (PJBBL) model

(3) Algorithm design and analysis ability test

Data Collection and Analysis : questionnaire, achievement of algorithm design and analysis ability and t-test

7. RESEARCH RESULTS Results of student' needs

The content of the student needs questionnaire was divided into five dimensions, including Students' experience of traditional learning models, Students' needs for algorithm design and analysis ability, Students' demand for autonomous student ability, Students' family with teaching software, Students' understanding of the new teaching model. Each dimension included a total of 25 questions. Five experts were invited to conduct an IOC test on the student needs questionnaire. According to the IOC results, the IOC values for these five dimensions ranged between 0.6 and 1, all surpassing the threshold of 0.5. This signified that the questionnaire questions had successfully undergone the effectiveness test and could be distributed to students for questionnaire surveys.

Table 1 The result of questionnaire Reliability

Dimensions(Question)	Cronbach's Alpha value
Students' experience of traditional learning models	0.89
Students' needs for algorithm design and analysis ability	0.72
Students' demand for autonomous student ability	0.73
Students' familiarity with teaching software	0.74
Students' understanding of the new teaching model	0.88
Total questions	0.93

Then 30 students were invited to conduct reliability tests on the student needs questionnaire.. These 30 students filled out the corresponding questions in the questionnaire based on their actual situation. Conduct reliability testing on the questionnaire and obtain a reliability score of 5 dimensions. The Alpha value were 0.89, 0.72, 0.73, 0.74, and 0.88, respectively, as shown in Table 1. All dimensions' Alpha values were all greater than 0.7, indicated that the questionnaire passed the reliability test.

Randomly sampled 100 students and conducted a questionnaire survey to assess their needs across five dimensions. The results are presented in Table 2 below.

Table 2 The total Mean and Standard Deviation of student needs

Five aspects of student needs	**Mean**	**Std. Deviation**
students' experience of traditional learning models needs	4.43	0.55
students' algorithm design and analysis abilities needs	4.37	0.45
students' demand for autonomous student abilities needs	4.39	0.56
students' familiarity with teaching software needs	4.41	0.45
students' understanding of the new teaching model needs	4.42	0.44

From Table 2, the mean values of the 5 dimensions ranged from 4.37 to 4.43. The mean value for each dimension was greater than 4, indicating that students were willing to participate in the experiment of the PJBBL learning mode and expected the new learning approach to yield better improvements in algorithm design and analysis abilities.

Results of PJBBL Model

Having summarized the students' needs and carefully considered their key concerns, the following analysis was derived, leading to revisions in the model:

(1)Taking into account students' preferences for traditional learning models, it was believed that providing a pre-class overview of the current curriculum was valuable for establishing clear learning objectives. Therefore, explanations of the content for each session were incorporated.

(2)From the perspectives of students' attitudes toward teaching software and their understanding of new learning models, they were of the opinion that incorporating micro-courses and video instruction in the learning process could enhance students' learning efficiency.
(3)Considering the students' demand for algorithm design and analysis courses, it was apparent that improvements in learning methods, learning environments, and flexible assessment methods had the potential to enhance the quality of algorithm design and analysis education.
(4)Students eagerly anticipated the new learning mode, particularly regarding anticipated changes in assessment methods, learning content, and instructional approaches.
Through theoretical analysis, combined with the students' needs, it was observed that the PJBBL model in this study can reflect the characteristics of project-based teaching and blended teaching, and can be effectively utilized in the learning of algorithm design and analysis courses. Through the design and development of the project, the model incorporated knowledge from algorithm design and analysis courses, improving the ability of algorithm design and analysis. Through online and offline teaching activities, the ability to learn independently was enhanced. The model includes six links, all of which integrate online and offline blended learning.
Build Project: Through online and offline teacher and student activities, completed the establishment of the project and the analysis of project requirements.
Scenario Construction: Completed project development and curriculum learning environment construction through online and offline teacher and student activities.
Divisions of Student Roles: Through online and offline teacher and student activities, students were grouped and assigned roles within their respective groups.
Project Plan: Completed the work plan for each group to carry out projects through online and offline teacher and student activities.
Project Implementation: Through online and offline teacher and student activities, learned course knowledge and applied it to develop every function of the project.
Project Evaluation and Improvement: Evaluated the projects implemented by each group through online and offline teacher and student activities, and provided improvement suggestions.
The final PJBBL model was shown in the following figure.

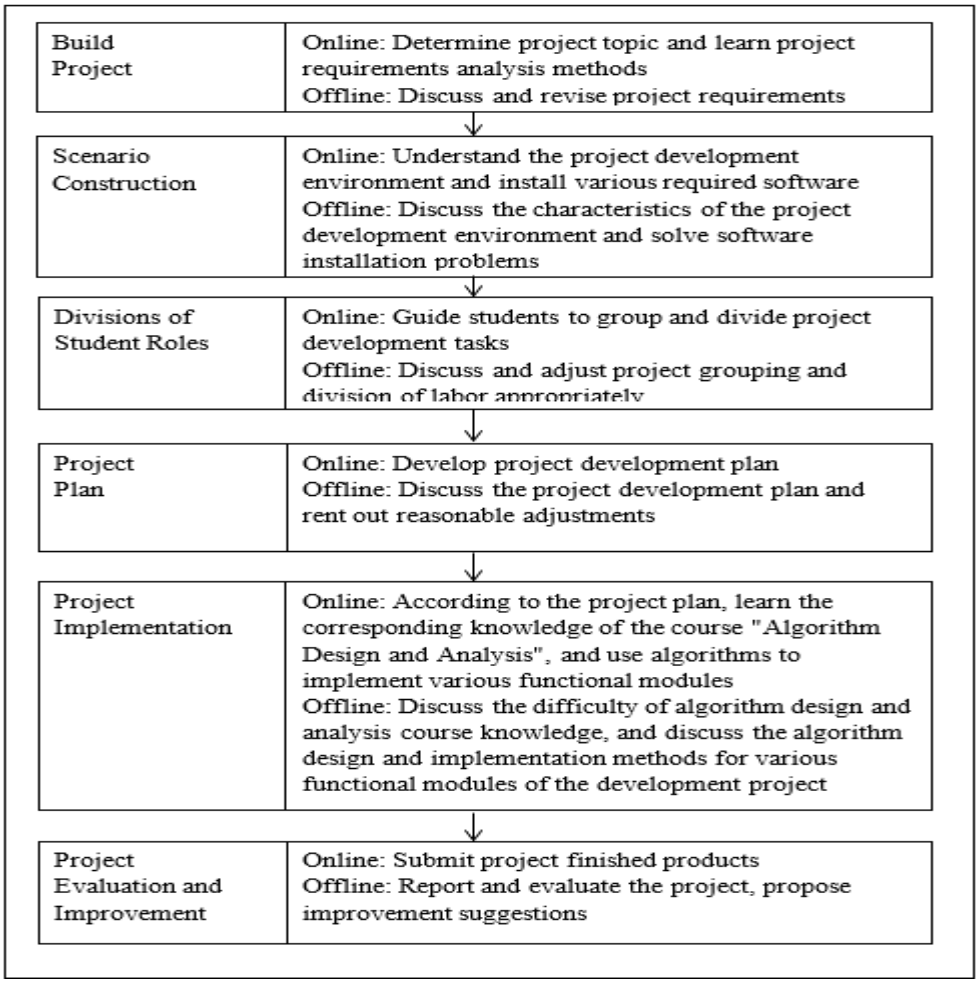

Figure 2 PJBBL Model

The Results of PJBBL Model in Algorithm design and analyze Ability

The PJBBL learning model and traditional learning model were used to study algorithm design and analysis courses in the experimental group and control group, with 33 participants in the control group and 36 participants in the experimental group. After completing the course experiment, achievement were conducted on both groups to obtain scores that reflected the students' algorithm design and analysis abilities.

Firstly, achievement of algorithm design and analysis ability of the experiment group and the control group were checked for normality, as shown in Table 2. The sig values in Shapiro Wilk were 0.814 and 0.635, respectively, both greater than 0.05, indicating that the scores of the two groups were normal.

Table 2 Tests of Normality about Control group and Experiment group

	group	Shapiro-Wilk		
		Statistic	df	Sig.
Achievement of algorithm design and analysis ability	Control group	0.98	36	0.814
	Experiment group	0.98	33	0.635

Secondly, T-test was performed using achievement of the experimental group and the control group, as shown in Table 3.

Table 3 t-test of Achievement

Group	N	Mean	Std. Deviation	Levene's Test for Equality of Variances		t	df	Sig. (1-tailed)
				F	Sig.			
Control group	36	64.17	13.91	2.71	0.104	-2.89	67	0.003
Experiment group	33	72.73	10.24					

The Sig value of Levene's Test in the table was 0.104, greater than 0.05, indicating that the homogeneity of variance between the experimental and control groups was consistent. The Sig (1-tailed) value of the t-test was 0.003 and less than 0.05, indicating a significant difference in the achievement of algorithm design and analysis ability between the experimental group and the control group. The Mean value of the experimental group was 72.73, which was greater than the Mean value of the control group, which was 64.17. It could be observed that the achievement of the experimental group was significantly higher than that of the control group.

8. CONCLUSION AND DISCUSSION

8.1 Conclusion

Conclusion of the analysis of students' needs

In order to seek a new learning model and improve students' algorithm design and analysis abilities, a needs analysis of the new learning model was conducted for students. The following is the conclusion of the analysis for student' needs

The student needs analysis includes five dimensions: students' experience of traditional learning models; students' needs for algorithm design and analysis ability; students' demand for autonomous student ability; students' familiarity with teaching software; and students' understanding of the new teaching model. Based on these five dimensions, a student needs survey questionnaire was designed.

From the results of a questionnaire survey of 100 students' needs, it can be seen that students have the greatest opinion on traditional learning. They hope to increase their interest in learning, change the classroom learning atmosphere, and use various learning software to improve learning efficiency. With the help of the new learning mode, they can improve their algorithm design and analysis abilities by formulating reasonable learning goals, learning plans, assessment methods, and other methods, and improve their algorithm design and analysis abilities.

In summary, in this study, data and conclusions were analyzed by designing the needs of students and using questionnaire surveys. It indicated that students had shown fatigue and dissatisfaction with the traditional learning mode and had hoped to use the new learning mode of PJBBL to change the learning situation. With the help of

some teaching software and platforms, students' algorithm design and analysis abilities could be improved. Overall, the needs of students were urgent.

Conclusion on Algorithm Design and Analysis Ability of the PJBBL Model

A teaching experiment was conducted on the PJBBL learning model in the experimental group, with 36 participants in the experimental group. A teaching experiment on the traditional learning model was conducted in the control group, with 33 participants in the control group. After completing the teaching experiment, two groups of students were tested on their algorithm design and analysis abilities using the algorithm design and analysis ability test paper, and their test scores were collected separately.

Normallity testing was performed on the test results, and both sets of data conformed to normal characteristics. Then, the mean and standard deviation of the experimental and control groups were calculated, where the mean value of the experimental group was 72.73 and the mean value of the control group was 64.17.

Finally, to determine whether there was a significant improvement in algorithm design and analysis courses between the experimental group and the control group, a t-test analysis was conducted on the test scores of the two groups. From the inspection results, the sig value was less than 0.05, indicating a significant statistical difference between the experimental group and the control group, with the mean value of the experimental group being greater than the mean value of the control group. This also indicated that the PJBBL model was helpful in improving algorithm design and analysis capabilities.

In summary, the PJBBL learning model was applied in the teaching of algorithm design and analysis courses. The model integrated course knowledge into the project and allowed students to learn algorithm design and analysis knowledge during the project development process, enabling them to better grasp algorithm design and analysis knowledge and its application skills, and significantly improved their algorithm design and analysis abilities.

8.2 Discussion

Discussion on the needs of students

The student needs analysis questionnaire includes five dimensions: students' experience of traditional learning models, Students' needs for algorithm design and analysis ability, Students' demand for autonomous student ability, Students' familiarity with teaching software, Students' understanding of the new teaching model, each with 5 questions designed, totaling 25 questions

The logical relationship of questionnaire design is as follows: Firstly, we investigated students' opinions on traditional teaching models, especially their opinions on learning processes, learning atmosphere, learning motivation, and learning environment, to understand students' fundamental reform intentions. Secondly, we investigated the needs of computer science and technology students for algorithm design and analysis abilities, investigated the impact of learning methods, content, and foundation on course learning and abilities, and understood students' willingness to learn about the course. The third survey investigated students' needs for self-directed learning ability and understood the current situation of students' self-directed learning ability from aspects such as importance, course relationships, learning methods, learning environment, and learning plans. The fourth test examined students' understanding of teaching software and personal information literacy and conducted a survey on aspects such as learning effectiveness, learning resources, commonly used software, and software adaptability. The fifth survey investigated the needs of students to participate in the new PJBBL model, including school evaluation, learning processes, adaptability, and learning expectations. The requirements of the previous step were closely linked to the requirements of the next step, progressing layer by layer.

In summary, the design of demand analysis content for students was interrelated in every dimension, from proposing reforms to traditional learning methods to ultimately using new learning models to improve students' algorithm design and analysis abilities. The purpose of demand analysis was clear, closely related to the evaluation indicators of algorithm design and analysis ability, and the design of demand analysis could be considered relatively reasonable.

Discussion on the Implementation Effect of PJBBL Model

Comparing the research and experimental results of Anwar et al. (2022), Naragund and Handur (2013), and Sari et al. (2022) in project-based learning, blended learning, algorithm design and analysis courses, it can be observed that these scholars demonstrated positive improvement effects through achievement , and related scale analyses within their respective research scopes. After implementing the PJBBL model in this study, the students' algorithm design and analysis abilities were assessed using achievement papers. In terms of statistical significance, it was conclusively demonstrated that the PJBBL model effectively enhanced algorithm design and analysis abilities. Overall, this aligns with the initial hypotheses of this study, highlighting the value of the PJBBL learning model in improving algorithm design and analysis abilities.

9. RECOMMENDATIONS

(1) Emphasize individual learning and development: The experimental data from the PJBBL learning model revealed overall improvements in the algorithm design and analysis abilities of the students in the experimental group. However, there was a lack of focus on individual development. Future efforts should concentrate on supervising and supporting individual learning, emphasizing personalized education and nurturing each student with a humanistic approach, ensuring that more students can benefit from the outcomes of PJBBL learning.

(2) Expand the development of learning resources: It is imperative to consistently augment the learning resources for the courses, encompassing project cases, course video materials, and question banks tailored to the curriculum. A comprehensive practical learning platform should be established, incorporating course knowledge points, facilitating online learning and discussions, providing training through question banks and analytical Q&A, and supporting the coordinated integration of diverse learning software, project management, and quality control to achieve resource synergy.

(3) Integrate multiple learning modes: PJBBL primarily combines project-based learning and blended learning, designed to cater to various types of courses and diverse student profiles, including less proactive learners. It's beneficial to explore the integration of multiple learning modes to expand PJBBL further. For instance, incorporating a case study mode for law-related courses or introducing a flipped classroom learning approach for students who are less self-initiated. By innovatively expanding PJBBL, it's possible to achieve a more comprehensive integration of various learning methods.

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