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Improvement Of Algorithm Design And Analysis And Autonomous Learning Ability By Project-Based Blended Learning (PJBBL) Model For Undergraduate Students

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ABSTRACT:

Algorithm design and analysis ability reflects the basic abilities of computer science students, and autonomous learning ability is related to their development potential. Research and develop Project-Based Blended Learning

PJBBL） Mode to change traditional learning methods and improve the algorithm design and analysis ability and autonomous learning ability of computer science students.The PBBL model has been revised multiple times using methods such as literature research, teacher needs analysis, and focus group discussions.This model includes six stages: build project , scenario construction, divisions of student roles, project plan, project implementation, project Evaluation and improvement. all of which integrate blended learning both online and offline. Experiments were conducted to verify the effectiveness of the PBBL model.The experimental group comprised 36 participants, while the control group consisted of 33 participants. The algorithm design and analysis course learning in the experimental group utilized the PJBBL model, whereas the control group followed the traditional learning model. Following the completion of the experiment, achievement were administered to assess the algorithm design and analysis abilities of both the experimental and control groups. Subsequently, an evaluation of autonomous learning ability was conducted, and data analysis was performed using MANOVA. Levene's test revealed that the Sig. of the achievement in both the experimental and control groups was 0.104, while the Sig. of autonomous ability was 0.066, with both values exceeding 0.05, indicating similarity in variance between the groups. The achievement MANOVA was a significance value of 0.005, and the autonomy ability score was 0.000, both of which were less than 0.05. These results indicated a significant difference between the two dependent variables, achievement and autonomous ability, when comparing the experimental and control groups.

Keywords *Algorithm Design and Analysis Ability, Autonomous Learning Ability, Project-Based Blended Learning(PJBBL), Learing Model for Undergraduate Students, Blended Learning.*

1. INTRODUCTION

The rapid development of information technology and the arrival of the AI era, society needs a large number of computer talents. In Europe, the demand for computer talent is rapidly increasing: the European Commission (2016) stated that, by 2020, the EU will need about 900,000 new IT professionals to fill the market gap, also stated "there are currently not enough skilled professionals to meet the demand for IT positions, and this demand is growing faster than the entire labor market." Similarly, there is a high demand for computer talent in the United States. The U.S. Bureau of Labor Statistics (2020) estimated that from 2019 to 2029, the employment of computer and information technology professions will increase by 11%, far above the average level of all professions. In Asia, the demand for computer talent is also on the rise, especially in countries such as India and China. According to a report by the India Brand Equity Foundation (2021), the IT industry in India is expected to grow by 7.7% in 2021, adding approximately 138,000 new employees.

Traditional academic courses focus on theoretical knowledge, laying a solid foundation for subsequent academic research and discovering new knowledge in future academic fields (Cohen & Baruth, 2017). It is even more necessary to cultivate talents with engineering practice and application abilities. To highlight cultivation of good self-learning ability, scientific thinking mode, ability to propose, analyze, and solve problems, and enable students to grow into professional engineers with solid professional foundation, innovative ability, high comprehensive quality, strong development potential and social adaptability in computer education, urgent reform of teaching methods is needed (Mitchell et al., 2021).

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Therefore, to improve the algorithm design and analysis ability of computer major students and enhance their autonomous learning ability during learning, a combined learning model should have been constructed by combining project-based learning and blended learning methods.

2. RESEARCH QUESTIONS

(1) How to develop project-based learning model based on blended learning in the course?

(2) Whether the project-based blended learning（PJBBL） model improve students algorithm design and analysis ability and autonomous learning ability of compared with traditional teaching methods?

3. OBJECTIVES OF THE RESEARCH

(1) To develop the project-based blended learning model in the course.

(2) To study the effect of the project-based blended learning model on achivermnet and autonomous learning ability.

4. LITERATURE REVIEW

4.1 Overview of project-based learning(PJBL)

De Graaf & Kolmos (2007) believed that the true maturity and development of PJBL occurred after the mid-1960s. On the one hand, new developments in learning theory, including cognitive psychology and situational learning theory, further deepened the understanding of PJBL. On the other hand, the disconnect between school education and industrial practice further promoted the development of overall and linear models.

Burlbaw et al. (2013) expanded the extension of the concept of 'project' to define it as' wholehearted and purposeful actions carried out in a social environment '. On this basis, the "project approach" is defined as a method of organizing school curriculum and teaching by using students' wholehearted and purposeful actions as learning units.

Mooney (2000) believed that the above definition of "project-based approach" by Klebsky fully unifies important aspects of the educational process such as "action factors", "learning laws", and "moral qualities of behavior", making "project-based approach" universally applicable in different disciplines and interdisciplinary teaching.

Wolk (1994) proposed that the mainstream "project method" model consists of four points: (1) determining the purpose, that is, students set learning goals based on their interests; (2) Developing a plan, that is, developing a learning plan to achieve learning objectives, is the most difficult and crucial step in designing teaching methods; (3) Implement a plan, which refers to the process of students achieving learning objectives; (4) Evaluate the results, that is, evaluate the learning outcomes in multiple ways.

PJBL was a method that relied on acquiring knowledge during project design and implementation, providing a high level of authenticity. Throughout the learning process, individuals could grasp how to apply skills, which proved beneficial for enhancing their professional abilities.

4.2 Overview of blended learning

Alammary (2022) proposed a classification system for blended teaching modes that included three categories: low-intensity blending, medium-intensity blending, and high-intensity blending. In low-intensity blending, online courses were simply added as supplements to face-to-face courses. Medium-intensity blending involved replacing some face-to-face courses with online course activities. High-intensity blending entailed a complete redesign of the course content to more fully integrate online and face-to-face instruction.

Blended learning became a popular and effective training mode, as demonstrated by the research of Norberg et al. (2011), which showed its positive impact on student performance across various contexts, including higher education, adult education, and workplace training. To maximize the benefits of blended learning, Kalina & Powell (2009) suggested that control be exerted over learning content, pace, timing, and location to enhance the learning experience. Real-time data analysis conducted by Horn & Staker (2011) revealed that blended learning allowed teachers to tailor instruction according to students' cognitive levels, offering opportunities for personalized learning experiences.

Blended learning was not only about moving traditional offline learning online, but also about combining courses, content, and progress, leveraging the advantages of both online and offline learning to improve the quality and efficiency of learning.

4.3 Algorithm design and analysis ability

Algorithm design and analysis ability referred to the capacity to choose suitable algorithms for problem-solving, design, optimization, and analysis. It played a pivotal role in computer science, informatics, and related domains, encompassing the following elements: algorithmic knowledge, algorithm design, algorithm optimization, algorithm analysis, and programming implementation (Tang et al., 2020).

Project-based learning gained popularity in recent years as a method for instructing algorithm design and analysis skills. Through the creation and execution of hands-on projects, this approach facilitated students in acquiring a profound comprehension of the fundamentals of algorithm design and analysis, fostering independent thinking and problem-solving abilities (Doddamani, 2018).

Another effective teaching approach was cooperative learning, which helped students understand and master algorithm design and analysis skills more effectively. In cooperative learning, students supported each other and solved problems together, which improved their learning results and practical application abilities (Bernard & Bachu, 2015).

Case teaching was grounded in the analysis of case studies and assisted students in grasping the principles of algorithm design and analysis. By examining case studies, students gained a better understanding of real-world application scenarios and challenges related to algorithm design and analysis, which in turn allowed them to acquire algorithm design and analysis skills more effectively (Zhao & Li, 2020).

Algorithm design and analysis ability was a fundamental professional skill that computer students should have possessed. The application of multiple learning methods in this course played a promoting role. Further research on how students could actively learn and master this ability to better adapt to the rapid development of algorithm technology.

4.4 Overview of autonomous learning ability

Little (1996) believed that autonomous learning ability involved a person's capacity to autonomously make decisions, recognize, reflect upon, and take action on various matters. Benson (2007) defined autonomous learning as the capability to manage one's own learning. Duan (2008) highlighted that autonomous learning ability was a skill that demanded learners to depend on their own learning style, comprehend their individual learning circumstances, and take responsibility for their own learning.

Zimmerman (2002) developed an Self-Regulated Learning Questionnaire (SLQ) to assess students' autonomous learning abilities and behaviors, including measurement indicators for dimensions such as learning goals, learning strategies, learning emotions, and learning behavior.

The Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al.(1993) is a widely used self-report instrument to measure students' motivation and cognitive and metacognitive strategies for learning. The MSLQ consists of 81 Likert-type items, and measures students' use of various learning strategies in five domains: self-efficacy, intrinsic value, test anxiety, cognitive strategies, metacognitive self-regulation.

Autonomous learning ability was of great help to students' learning. Research was conducted to improve students' autonomous learning ability through changes in learning modes, and effective scales were used to measure and verify the effectiveness of these learning modes.

5.CONCEPTUAL FRAMEWORK

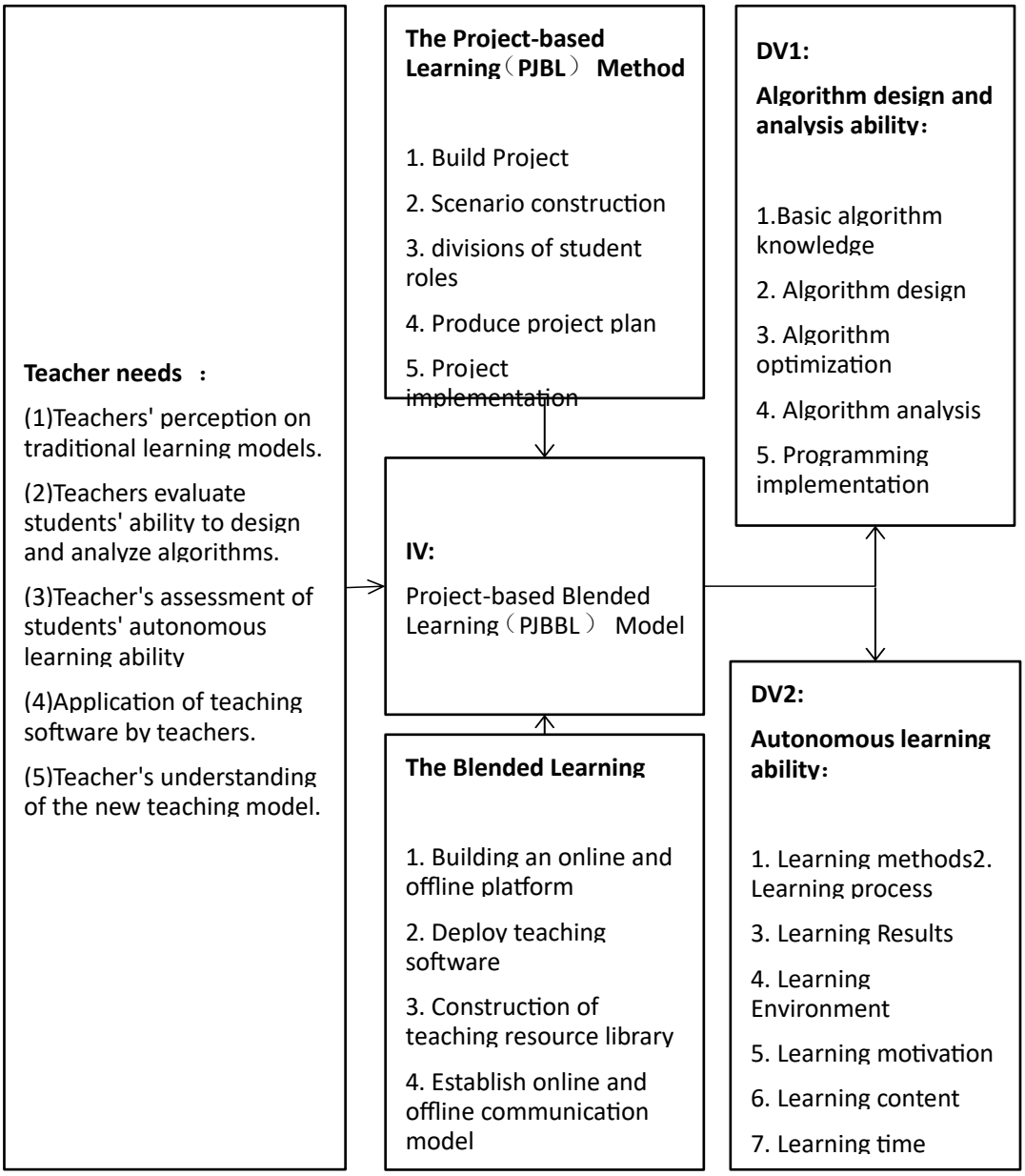

Figure 1 Research Framework

6. RESEARCH METHODOLOGY Research Process

Phase 1： develop project-based blended learning（PJBBL） model

This research phase was mainly focused on the development of a new learning model and consisted of two parts. One part involved designing the new model, and the other part involved analyzing and selecting the measurement tools used in the experiment.

Phase 2： study effects of the project-based blended learning（PJBBL） model

The main purpose of this study was to conduct experiments to investigate the impact on students' algorithm design and analysis ability and autonomous learning ability. It primarily encompassed three aspects: experimental design, determination of participants, and selection of data analysis methods.

Population and Sample

Population and sample: 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) Interview forms about teacher needs and focus group

Interviews had five aspects, including their views on traditional learning models, their assessment of student autonomous learning ability, their assessment of computer-related majors' current ability to design and analyze algorithms, the teacher' application of teaching software, and the teacher' understanding of the new PJBBL learning mode.Five experts were invited for teacher needs interviews.

A focus group consisting of five experts evaluated each step of the PJBBL model.

(2) Algorithm design and analysis ability test

The test paper included 5 parts: algorithm basics, algorithm design, algorithm optimization, algorithm analysis, and program implementation. There were 20 questions, totaling 100 points.

(3) Scale of autonomous learning ability

The scale included 7 first level indicators and 20 second level indicators. The scale incluled 7 parts: learning method, learning process, learning results, learning environment, learning motivation, learning content, learning time.

Data analysis: MANOVA

7. RESEARCH RESULTS Verification Results of PJBBL Model

This section modified the PJBBL model based on the needs of teachers, in conjunction with the first step PJBBL version (PJBBL v1.0) related to PBL and the Blended Learning Model mentioned in the literature review. The second step involved the creation of the second PJBBL version (PJBBL v2.0). A focus group was conducted once again to discuss PJBBL (v1.0 version). The opinions of five experts were gathered and synthesized to further refine and enhance the PJBBL model, resulting in the development of PJBBL (V3.0). The model correction process is depicted in the following figure:

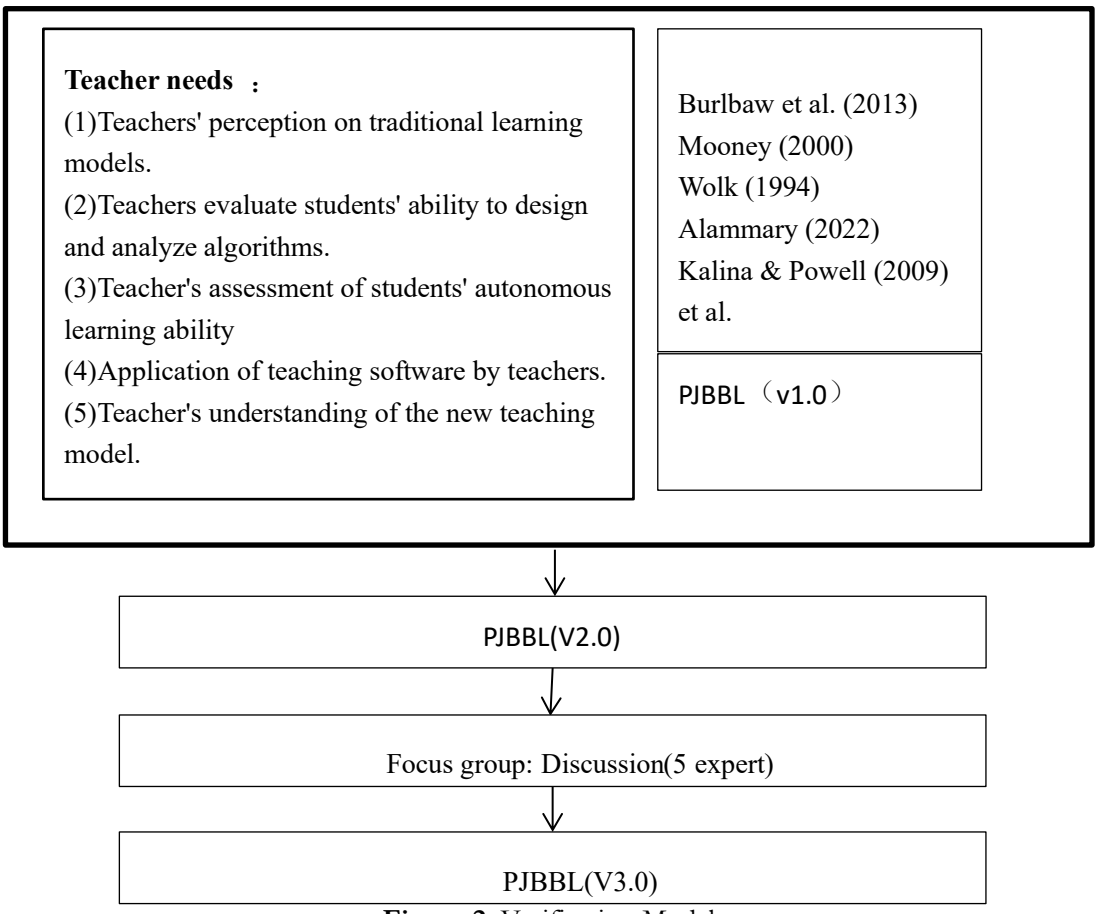

Figure 2 Verification Model

The PJBBL (v3.0) model could reflect the characteristics of project-based teaching and blended teaching, and was well utilized in the learning of algorithm design and analysis courses. Through project design and development, the model learned algorithm design and analysis course knowledge, improved algorithm design and analysis ability,

and enhanced autonomous learning ability through online and offline teaching activities. The model included six steps, all of which integrated online and offline blended learning.

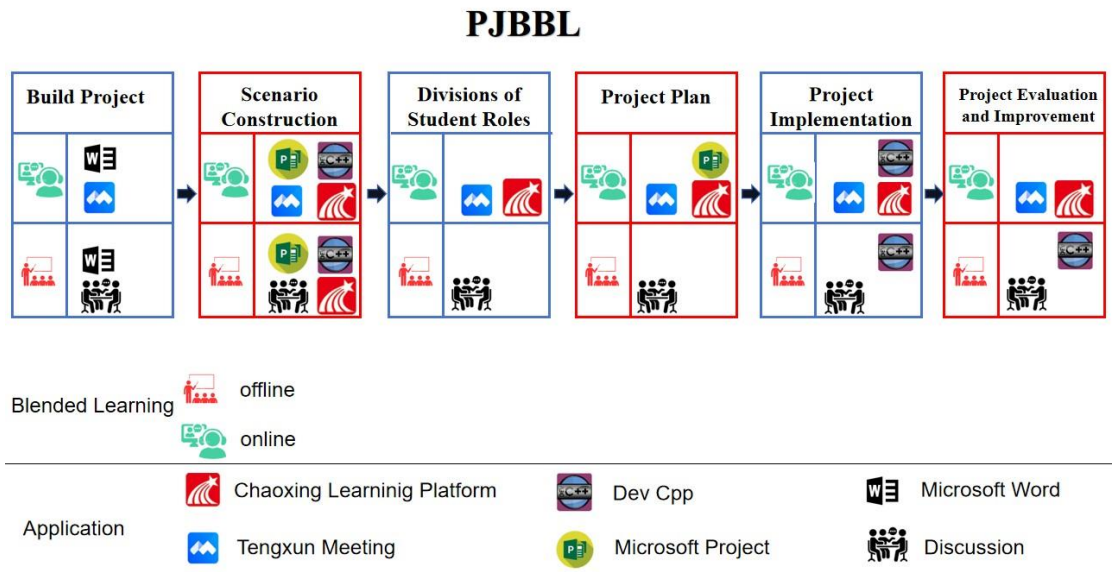

Figure 3 PJBBL Model

The Results of PJBBL Model in Algorithm design and analyze Ability and Autonomous Learning Ability

Firstly, an experimental group and a control group were designed, consisting of 36 participants in the experimental group and 33 participants in the control group. Pre-tests were administered to both the experimental and control groups to assess the differences between the two groups. The pre-test papers used by both groups were identical, and the pre-test scores of each group of students were recorded. The pre-test data from both groups of students underwent a t-test, and the results are presented in Table 1:

Table 1 Result of Pre-test

Group	Number	Means	SD.	Levene's test	
				F	Sig.
controlGroup	36	50.69	13.05	0.44	0.51
experimentGroup	33	50.45	12.33		

In the table, the mean values for the control group and the experimental group were 50.69 and 50.45, respectively, with standard deviations of 13.05 and 12.35. The significance (sig) value of Levene's test was 0.51, which was notably higher than 0.05. It can be observed that there was no significant difference in the pre-test scores between the control group and the experimental group, indicating that there was no substantial disparity in the level of knowledge mastery in the algorithm design and analysis course between the two groups of students participating in the experiment.

Then, the experimental group used the PJBBL model for learning algorithm design and analysis courses, while the control group employed traditional learning models for the same purpose. Upon course completion, the algorithm design and analysis abilities of both student groups were assessed through achievement, and the resulting scores were recorded. An expert evaluated the autonomous learning ability of the two groups using an autonomous learning ability scale and recorded the evaluation scores. To ascertain whether there were significant differences in algorithm design and analysis ability and autonomous learning ability between the experimental and control groups, a MANOVA was conducted to analyze the two dependent variables: achievement scores and autonomous learning ability scores. The outcomes are detailed in Table 2 and Table 3.

Table 2 Multivariate Tests

Effect	Value	F	Sig.
Wilks' Lambda	0.66	16.94[a]	0.000

From table 2, it can be seen that the sig value corresponding to Wilks' Lambda is 0.000, less than 0.05, indicating that at least one variable exhibits differences between the experimental group and the control group.
The specific differences are shown in the following table 3:

Table 3 Result of cooperation the achievement and autonomous ability

DV	IV	number	means	SD.	Levene's test		F	Sig.
					W	sig		
Achievement	Control group	36	64.17	13.91	0..104		8.35	0.005
	Experiment group	33	72.73	10.24				
Autonomous Ability	Control group	36	67.00	9.95	.066		33.22	0.000
	Experiment group	33	79.36	7.59				

From table 3, it can be seen that the sig value of ANOVA corresponding to the achievement were 0.002 and less than 0.05, indicating a significant difference between the control group and the experimental group. Then observe the achievement, where the mean value of the control group were 64.17, SD were 13.91, and the mean value of the experimental group were 72.73, SD were 10.24, indicating that the achievement of the experimental group are better than those of the control group, indicating that the algorithm design and analysis ability of the experimental group were higher than that of the control group. Finally, the evaluation score of autonomous learning ability was observed, with the control group having a mean value of 67.00 and an SD of 9.95. The experimental group had a mean value of 79.36 and an SD of 7.59, indicating that the autonomous learning ability of the experimental group was higher than that of the control group.
In summary, in the absence of significant differences in the pre-test data, the application of the PJBBL learning model in algorithm design and analysis teaching has a significant improvement effect on students' algorithm design and analysis abilities and autonomous learning abilities.

8. CONCLUSION AND DISCUSSION

8.1 Conclusion

Conclusion on Developing PJBBL Model

The PJBBL (v3.0) learning model integrates blended teaching and project-based teaching, reconstructs the knowledge of algorithm design and analysis courses, and integrates the cultivation of autonomous learning ability into the teaching activities of teachers and students. The model consists of six stages: build project, scenario construction, divisions of student roles, product project plan, project implementation, project evaluation, and improvement. Each stage includes online and offline teaching, with teachers and students conducting teaching activities, learning course knowledge, and training self-directed learning abilities online and offline, respectively.
Build Project Phase: This phase requires a clear understanding of the theme and requirements of the development project.
Scenario construction stage: In this stage, it is necessary to establish a good development environment and learning environment based on the characteristics of the development project.
Divisions of student roles section: In this section, groups and assign roles within the group based on the workload of the project.
Production project plan stage: In this stage, each group formulates a reasonable project development plan.
Project implementation stage: In this stage, while learning course knowledge, apply course knowledge to project development.
Project evaluation and improvement stage: In this stage, the overall evaluation and improvement of the project are carried out.

Conclusion on Improving Algorithm Design and Analysis, and Autonomous Learning Ability of PJBBL Model

Teaching experiments were conducted using the PJBBL learning model and the traditional learning model in the experimental group and control group, respectively. Students underwent testing of their algorithm design and analysis abilities and evaluation of their autonomous learning abilities using achievement and expert scoring methods.

The achievement data of both the experimental group and the control group, along with the data from the autonomous learning ability assessment scale, underwent MANOVA analysis. The results revealed a significant difference between the experimental group and the control group in the two dependent variables of achievement and autonomous ability. These specific differences were compared and analyzed based on the mean and variance in the table. For the achievement, the control group's score (mean=64.17, SD=13.91) was significantly lower than the experimental group's score (mean=72.73, SD=10.24). Similarly, for autonomous ability, the control group's score (mean=67.00, SD=9.95) was also significantly lower than the experimental group's score (mean=79.36, SD=7.59). The achievement ANOVA was a sig value of 0.005, and the autonomy ability also had a significance value of 0.000, both of which were less than 0.05. These data indicated that, during that time, the control group and experimental group had achieved higher scores than the control group in both achievement and autonomous ability, with no significant difference in pretest results, signifying a statistically significant difference.
In summary, the application of the PJBBL learning model in algorithm design and analysis teaching has a significant improvement effect on students' ability to design and analyze algorithms, as well as their autonomous ability.

8.2 Discussion

In order to improve the shortcomings of traditional learning models, enhance students' ability to master professional knowledge, and enhance their ability to learn independently, a PJBBL school model was designed and developed. From literature research to combining the needs of students and teachers, the first revision was made, and finally evaluated by a focus group consisting of five experts. From then on, the final PJBBL (v3.0) version was developed.
In the literature, researcher's Luo (2020), Wei (2022), Yu (2019), etc. emphasized project design, project implementation, achievement display, and evaluation summary when designing PJBL models. Although there were some differences in the specific implementation process of their designed models, they all carried out teaching around the project as a carrier.
In the literature, researchers Zhao (2020), Shao (2022), etc. emphasized that when designing blended learning models, they should rely on teaching software to construct online and offline teaching, and move some teaching content from traditional online teaching to online teaching, which has high requirements for students' learning ability. Although each designed hybrid model has slightly different emphasis in specific aspects, they all divide teaching into online and offline parts.
Based on the description in the literature, combined with the needs of students and teachers, and combined with the evaluation of focus groups, a PJBBL learning model was developed. This model is jointly constructed by project-based learning and blended learning. PJBBL is divided into six stages: Build Project, Scenario construction, divisions of student roles, Produce Project plan, Project implementation, Project evaluation, and improvement. Each stage includes two parts: online learning and offline learning, and each stage has teacher and student activities, we have integrated blended teaching into all aspects of project-based teaching. Secondly, teaching software is used to assist in each teaching process, especially in the learning of course knowledge points. Through methods such as video learning, online meetings, project implementation and summary, teaching software is used to improve learning efficiency and enhance learning autonomy. During the project implementation phase, the course content of algorithm design and analysis was restructured, embedding basic knowledge of algorithms, recursive algorithms, exhaustive algorithms, divide and conquer algorithms, and other teaching content into the software project designed and developed.

9. RECOMMENDATIONS

(1) The formulation of project plans should be meticulous. The project plan is the foundation for ensuring the smooth execution of the entire teaching process. Teachers should actively assist students in making the plan and evaluate its rationality and feasibility. Because students participate in PJBBL learning for the first time and cannot grasp the learning progress and quality of the teaching content well, the teacher, together with the students, makes the project plan meticulous.
(2) Play the role of teacher guidance and student leadership. PJBBL has transformed the teaching subject from the traditional learning mode where teachers are the main body of teaching to students, all of which are improving students' autonomous learning ability. However, if teachers allow students to follow their own ideas in all aspects, there may be hidden dangers to the completeness of learning time, content, and achievement of learning outcomes. Teachers should provide appropriate guidance to ensure the smooth completion of teaching objectives.
(3) The design of teaching content should follow the basic principles of project management. The design of teaching content should not only be based on the arrangement of textbooks, but also on the division of learning content between online and offline. Especially, it is necessary to design the learning content of each link

reasonably based on the requirements of project management, and ensure the smooth mastery of the learning content during the project execution process by connecting the knowledge in sequence.

(4) The using of online teaching should focus on efficiency.

Online teaching can share some of the work under traditional learning modes, but it is necessary to improve the utilization rate of online learning, especially when using learning resources for autonomous or group discussions on course knowledge points online. The learning process and quality should be monitored to improve learning efficiency, otherwise it will have an impact on the application of knowledge to develop software projects.

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