

Research on Design of PBL in Blended Learning Environment—Aiming at Promoting Students' Deep Learning

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Abstract—The rapid social development has brought about changes in the field of education. More and more precise division of labor has also put higher demands on the effectiveness of education. Under the background of education reform, many educational methods and educational concepts that conform to the requirements of the times have come into being, such as project-based learning, blended learning and in-depth learning. Through literature review and field research, it is found that although project learning and blended learning bring new vitality to the traditional classroom, there are also some shortcomings. For example, in the project-based learning, the interaction between teachers and students is not timely and the learning resources are not sufficient. The shallow learning brought by digital reading in blended learning will affect the teaching effect. However, they also have the advantage of being complementary in each other. That is to say, blended learning can provide a convenient and interactive platform for project-based learning and a rich variety of learning resources. Project-based learning can enrich the offline activities of blended learning, and help to promote the deep learning of students. Therefore, by studying papers and excellent cases both at home and abroad, this study summarizes the curriculum framework and key links of project-based learning, blended learning and in-depth learning respectively, and explores the effective combination of the former two to promote the students' deep learning. And then put forward the corresponding curriculum framework, a total of educators for reference.

Index Terms—PBL, blended learning, deep learning

I. INTRODUCTION

PBL (Project-Based Learning) has been studied for many years, and its educational effect has been widely recognized. However, there are few PBL teaching cases in primary schools and most of the practice of PBL occurs in secondary schools and institutions of higher learning. [1] The cause of the phenomenon is that there are many contradictions between the planning and implementation of PBL and the existing education system, especially the contradictions between the requirements of the implementation of PBL about abundant teaching resources and the actuality of teachers' heavy workload.

Furthermore, the status that student's primary school are easily distracted and hard to manage.

With the popularity of computer technology, blended learning, which combines advantages of online education and offline education, came into being. Strengths for blended learning include breaking the limitation of time and space, realizing individualized learning, promoting the face-to-face interaction between teachers and students, ensuring the emotional communication between teachers and students, and enabling teachers to supervise and manage students more comprehensively. It has been found in studies of blended learning that blended learning can not only provide rich teaching resources for teachers and reduce their burden of preparation, but also can expand students' communication circle and improve the teaching efficiency. To a certain extent, this can promote the implementation of PBL in primary school classrooms.

While the development of things can always be double-sided. The advent of the Internet era has also brought a wave of fragmented reading, followed by the shallow learning of the general public. Shallow learning is just a repetitive memory of simple knowledge, lacking understanding, practice and application of knowledge. Therefore, more and more researchers attach importance to deep learning. Because the essence of deep learning fit in with the gist of PBL, the main concern of this study is how to implement PBL in a blended learning environment to promote students' deep learning.

Feng Ruiling reviewed the researches on web-based project-based learning from 2002 to 2012. Based on this review we can know that web-based project-based learning is effective, but teachers often confuse project-based learning with comprehensive practice in practice. [2] This means that although the emphasis on the effectiveness of PBLs has almost become a cliché it remains an open issue. People are still puzzled about how to systematically integrate technology into teaching, even their interest and enthusiasm in using computers and social networks are growing. To provide reference for teachers to practice, this study will discuss how to design project-based learning in a blended learning environment from the perspective of deep learning, and proposes a design framework for project-based learning in a blended learning environment.

II. THE RELATED COLLATION OF PBL

A. The Connotation of PBL

After the teaching mode of PBL appeared in Harvard Medical School in the United States in the middle of the last century, university workers first tried it in a teaching program called "MD Program" in 1965. At present, there are two versions of "PBL" translations, "problem-based learning" and "project-based learning." American scholars have now put forward "PPBL teaching model" further, the following will explain these three concepts.

1) Problem-based learning

The original meaning of PBL is "Problem-based learning". And this teaching model focuses on a realistic and complex issue, in which the teaching scenario is usually based on the reality of the teacher Hypothetical, requiring students to cooperate, exchange, and solve real problems to enhance their intrinsic motivation to learn. Because this teaching model is easier to implement in class than project-based learning, the teaching model of problem-based learning is rapidly gaining ground worldwide.

2) Project-based learning

Project-based learning was first proposed as "design learning" and it was a teaching method proposed by William Kilpatrick in early 20th century to improve the situation that learning content is single and boring and students could not solve practical problems. To understand what is "project-based learning," one must first know what a "project" is. In the book *Successful Project Management*, Jack Gido et al. defined "project" as "the effort to achieve a specific goal based on a set of

unique and interconnected issues (tasks) by making effective use of resources".[3] Zeng Hao et al., in "The First Project Manager," considered the "project" as "a time-limited and resource-limited task that required the creation of specific products and services".[4] So we can see that the concept of "project" includes the key words such as problem, product, task and design. Buck Institute for Education (BIE) defines project-based learning as "a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem, or challenge". Combined with the above concepts, the author thinks that the project-based learning is a time-limited and resource-limited teaching method that is project-oriented, supported by tools provided by teachers for students, based on student cooperation, and with the goal of producing works and solving real problems in real cases.

3) Problem- and project-based learning

Problem- and project-based learning, namely PPBL teaching method, originated in the United States. This teaching method mainly emphasis on student-centered and focus on student self-learning and inter-team collaboration learning, of which purpose is to solve a real scene in the actual problems, which may have some economic and social benefits or may also include some stakeholders. In other words, participants in the curriculum implementation process not only include teachers and students, meanwhile the teaching content and teaching effects are often related to the society.[5] Therefore, PPBL can be considered as a further extension of the project-based learning.

TABLE I. THE DIFFERENCES AMONG PROBLEM-BASED LEARNING, PROJECT-BASED LEARNING AND PPBL.

	Main learning place	Guide	Teaching situation	Involving disciplines	Learning motivation
Problem-based learning	Classroom	Teachers	Hypothetical scenarios based on reality	Often it is a single discipline, but it can also be an interdisciplinary discipline	Solving the problem
Project-based learning	Classroom and society	Teachers, governments (experts), enterprises, etc.	Real life	Often interdisciplinary	Outputting works to customers and solving real problems
Problem- and project-based learning	Classroom and society	Teachers, governments (experts), enterprises, etc.	Real life	Often interdisciplinary	Producing a certain degree of economic or social benefits and solving practical problems

Problem-based learning, project-based learning, and PPBL have the same theoretical foundation and similar expressions, but there are also differences among the three. We can see the differences in Table I, problem-based learning relies mainly on school education, in which classrooms are students' main learning places, where learning situations are assumed by the teacher, so the authenticity is lower; while project-based learning and PPBL takes advantage of the educational function of society which can help students integrate into society as

much as possible, so the training for students is more comprehensive. In addition, problem-based learning only requires students to solve the problem in the end; project-based learning and PPBL finally require students to produce works that have certain economic and social benefits.

By contrast, it can be seen that problem-based learning can exist independently as short-term project-based learning or as part of project-based learning at a certain stage of project-based learning. And the PPBL can be

seen as a further extension of the former two. Therefore, in the activity design of this study, the main reference is the curriculum framework of the first two.

B. Research on Curriculum Framework Design of PBL

PBL is more often translated as "problem-based learning", so this article will first introduce problem-based learning. In 1985, Harvard University examined the university's teaching model and formally introduced the problem-based learning teaching mode after researching and demonstrating. Since the question-based learning teaching mode has been applied in China, there are many examples and researches using this teaching mode in the country. The medical university first applied problem-based learning teaching mode in our country. In the higher medical university, a problem-based learning curriculum is usually designed by the teacher to combine the actual clinical cases with the actual medical scene into

a lesson plan, so that students can find information on their own and propose solutions through teamwork according to the problems that may be encountered in the situation. [6] The application of problem-based learning model in nursing are similar to those in medicine, for it is also conducted within the classroom, under the guidance of teachers, and through the process of asking questions—establishing hypothetical scenarios—obtaining information—group discussion about results—reflection and summarization. [7] As for the application in primary and secondary education, teachers have tried to conduct problem-based learning in the classical single-subject teaching of physics, chemistry, mathematics and English and it follows the above steps in general. Therefore, this study summarizes the process of problem-based learning as Fig. 1:

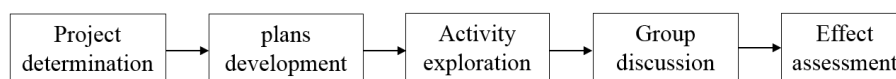


Figure 1. The process of problem-based learning summarized by this study.

Modern society pays more attention to the all-round development of learners, and educational practice gradually changes from question-based learning to

project-based learning. Han and Bhattacharya think that the steps of project-based learning implementation should look like Fig. 2:

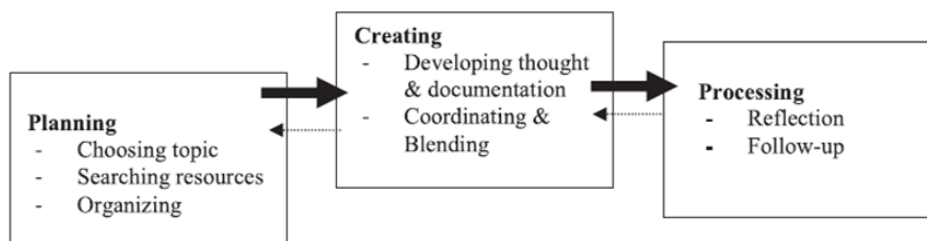


Figure 2. Phases for implementing PBL in the classroom (Han & Bhattacharya, 2001).

They divide project-based learning into three main parts: planning, creating and implementing. Each section is subdivided into two or three sections, which include the key steps of project identification, data collection and cooperative learning. [8] In order to meet the needs of learners, some Chinese teachers began to try the project-based learning teaching mode. For example, some primary school teachers made use of the break between two classes and community activities and developed project-based learning that combined with school-based curriculum. [9] Also in secondary schools, teachers used the platform of the school community to carry out project-based teaching mode combined school-based curriculum. [10] While in universities, teachers design and implement project-based learning programs in advanced mathematics and college English according to curriculum content. [11] In general, Chinese educators started an understanding change about PBL teaching mode from "problem-based learning" to "project-based learning". Feng Xiuqi and others summarize that the steps of project-based learning are to identify topics, group them, analyze problems and formulate research plans, collect information and validate explanations,

demonstrate learning outcomes and evaluations; Wang Hao has implemented the project-based learning teaching method in the science class of primary school and achieved good results according to the steps as problem determination—plans making—organization and implementation—results demonstration and assessment—filing and application. Therefore, based on the course flow of problem-based learning, this study refers to the design process of Wang Hao and Han et al. and determines the implementation process of the project-based learning as: problem determination, plans development, activities exploration, production making, demonstration and communication, and effect assessment. And the course flow can be summarized as Fig. 3.

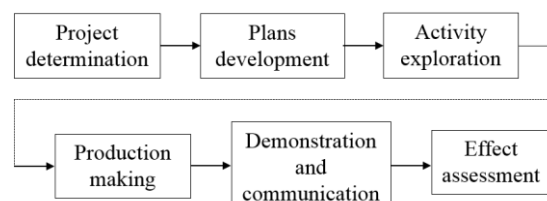


Figure 3. The course flow of the project-based learning.

PBL in the following part refers to project-based learning.

C. The Advantages and Disadvantages of PBL

In 1988, the United States implemented the PBL teaching model in primary, secondary and university in order to further improve students' interest in learning. They hope that this model will help students receive a comprehensive and coordinated development by enhancing their abilities to acquire and collect information, analyze and solve problems, unite and cooperate. [12] Among them, Abbot and Mitchell, as well as Vernon and Blake conducted a research on this teaching mode for nearly two decades. And by analyzing the results of routine knowledge testing, it was found that students trained under the PBL teaching mode are significantly better than those under the traditional model in solving problems and thinking patterns. [13] In other studies, the PBL teaching model also showed some advantages. For example, in the medical schools in North America, the enrollment rate of health major students trained by this teaching model has been significantly increased. [14] In the specific practice in China, PBL teaching mode also has the advantage of improving students' academic achievement and learning interest. In one study, most teachers said that project-based learning promoted active participation of students (95%), motivated them to study (96%), and helped them acquire a variety of curriculum skills (90%). [15] According to Blanchard, PBL reinforces the student's desire for autonomous learning, which helps to integrate knowledge in a practical way and produces relevant and meaningful learning. Project-based learning has become a process that can reduce the stress of the curriculum and encourage students to take the initiative to learn without compromising knowledge and basic skills. [16] Compared with problem-based learning, project-based learning provides students with more authentic learning situations and greater communication circle.

However, most teachers on campus prefer to use "problem-based learning" rather than "project-based learning". In view of this phenomenon, combined with the actual personal experience and literature reading, the author that think that "project-based learning" has few deficiencies: (1) the classroom efficiency is not high. While the self-control of students is limited, finding information is time-consuming and labor-intensive; (2) the workload of teachers has increased. PBL curriculum design requires teachers to prepare lessons according to the unit, semester or even school year, but also to deal with various unexpected situations during the implementation process, resulting in a significant increase in the workload of teachers; (3) project-based learning ignores the emphasis on basic knowledge. [17] The lack of timely communication with students during implementation process hinder students from deep learning; (4) teachers and students did not make full use of technical tools.

Considering the advantages and disadvantages of PBL and the ability of pupils themselves, this study decided to start with small projects and prepare lessons in units

when design activities. By combining the advantages of blended learning, this study supplemented the knowledge materials and learning bracket needed for PBL implementation.

III. BLENDED LEARNING

A. The Connotation of Blended Learning

The most straightforward and simplest definition of blended learning is proposed by Michael E.W and Frank J. T. in 2002. That is, blended learning refers to the blended learning model of E-Learning and traditional classroom learning. After that, Anthony made a comprehensive exposition of blended learning in two aspects in 2009, and proposed a general conception of blended learning. He extended "network" to "technology or media", and then considered blended learning as a learning paradigm that blends technology or media with traditional face-to-face classroom activities. [18] It can be seen that the earlier definition of blended learning only focused on its major extrinsic forms and lacked a description of its intrinsic characteristics. With the deepening of the research, people's understanding of blended learning is more in-depth and more specific, which also enriches the definition of blended learning.

Also in 2009, when academics such as Huang Ronghuai and Martin expressed their opinions on blended learning, they agreed with the views put forward by Singh and Reed, affirming the importance of the five "right" in blended learning, namely, the right time, right learning technologies, right personal learning style, right person and right skills. Singh and Reed think blended learning is the way in which the five "right" pieces work together to bring about the most optimal learning outcomes. [19] This description focuses more on learners than before, but the description of "right" is not practical enough and requires educational practitioners to keep trying in practice.

Allen and Seamen presented their understanding of blended learning definitions in 2010, making the "right" interpretation more manageable. The most important thing is that they think most of the time should be used to online learning and the learning content should be mainly on the Internet (the proportion of online content is 30% - 70%), and that blended learning can effectively shorten the face-to-face time of traditional teaching. Although this definition can provide teachers with behavioral guidance to help them plan their teaching hours and divide their teaching contents, this is only to describe the blended learning in terms of the proportion of the class, staying extrinsic model without revealing its essence and more in-depth description.

Chinese scholars also have different understandings of blended learning, and some definitions proposed by them have been widely acknowledged.

According to Professor He Kekang, blended learning is the result of the complementary advantages of traditional learning methods and E-Learning. That is to say, blended learning not only need to play the leading role of teachers in guiding, enlightening and monitoring the teaching process, but also need to fully reflect the initiative,

enthusiasm and creativity of students as the main body of the learning process. [20] This understanding includes not only different learning scenarios, but also two learning elements of teachers and students, having been widely recognized. The only drawback is that this understanding is not comprehensive enough for it understands "mixing" only as a mixture of "tradition" and "network."

Professor Li Kedong's point of view is similar to that of Professor He Kekang. Both of them think that blended learning should reflect both teacher-led and student-centered. Professor Li also views blended learning as a teaching model that can reduce cost while increase benefits by combining two learning modes, Face-to-Face and Online Learning. He stressed that blended learning should be "the lowest cost and most effective when it comes to solving problems". [21]

Based on the scholars' opinions above, the blended learning adopted in this study mainly includes the following aspects.

Blended learning styles: it means the combination of traditional face-to-face and online learning based on computer network technology and the combination of online learning and offline learning, organically combining various learning modes such as group collaborative learning and personalized self-learning.

Blended learning environment: it can mean that the real learning environment and virtual learning environment intersect or refer to the classroom closed environment and classroom open environment to cross, in order to achieve the integration of various types of learning resources;

Blended learning resources: from the point of view of form, it includes the intersection of video, text and concrete material; from the point of view of resources, it includes the intersection of network resource, teaching material resource and experimental resource;

Blended learning curriculum: from the point of view of curriculum, micro-course online video includes not only the relevant knowledge of a single subject, but also related to the basic knowledge of multidisciplinary, in line with the development trend of curriculum integration;

Blended learning experience: it includes learning experience both outside and inside the classroom, as well as offline learning experience and online learning experience. In practice, it protects the dominant position of students, to provide students with more sensory stimulation and enhance their sense of immersion.

B. Researchs on Curriculum Framework Design of Blended Learning

Through the review of dissertations and periodicals in China in recent ten years, Ma Zhiqiang *et al.* (2016) found that domestic research on blended learning focuses on "instructional design", "curriculum framework" and "technology application". Among them, Professor Li Kedong analyzed the theoretical basis, basic principle and application mode of blended learning. Then he designed a blended learning process based on the blended learning sections designed by Josh Bersin. The process includes determining learning objectives, determining expected performance, choosing delivery channels or media,

learning designing, supporting strategies, action observation, learning assessment and revision learning. Professor Huang Ronghuai proposed a framework of curriculum design in blended learning, namely three stages—"front-end analysis", "activities and resources design" and "teaching evaluation design". [23] In the study of blended learning model, Cao Xiaoming summed up the 3C model. In his view, blended learning can be divided into several stages: waking experience, perceptual learning, practical application, sharing, communication and reflection. Blended learning is task-driven and relies on the operation of learning circle, with real and specific tasks at the core of the entire learning process. [22] However, Chinese research focuses on the blended learning model itself, which treats the independent elements such as different learning resources, learning styles, learning tools and learning sites in blended learning as a unified whole, ignoring the nature of independent elements in "blended", thus diluting the characteristics and advantages of blended learning. Different from China, foreign studies are more inclined to specific teaching situations, proposing and verifying the blended teaching strategies and methods from a micro perspective. Some foreign studies have produced some teaching design ideas and guidance that can be referred to. For example, some researches have proposed the optimal practices for blended learning. The suggestions include: (1) 30% -79% of the content should be learned online; (2) offline activities can be supplemented by online content; (3) Reduce teaching time in class, but not completely cancel these times. [23]

	Classroom-Intensive Delivery	Hybrid Delivery
Lecture	Classroom ----->	Online
Quiz	Classroom ----->	Online
ALEs	Classroom ----->	<ul style="list-style-type: none"> Some Online Some in Classroom Some Web-Assessed in Classroom
Discussion	Classroom ----->	<ul style="list-style-type: none"> Some Online Forums Some in Classroom

Figure 4. A blended learning model put forward by Klotz *et al.*

Based on the scholars' opinions above, this study divides blended learning into five sections: course introduction, organizational activities, learning support, interaction and evaluation. [24] How to combine PBL with blended learning, also need to refer to specific cases. Taking the MBA course as an example, Klotz *et al.* put forward a blended learning model that can effectively shorten the time for studying in school while greatly improving student performance and student satisfaction, as shown in the following Fig. 4.

It can be seen that in this case information technology serves as a cognitive tool.

Chinese scholars Wu Xinxin, Dong Yan and others believe that in a blended learning environment, information technology can create context for the project-based learning, to provide diversified cognitive tools and a variety of evaluation tools. [25]

Therefore, in the process of design, this study applies information technology to every aspect of PBL, such as

creating situations in determining the project, acting as a cognitive tool in planning and exploring activities and making works, and referring to students' performance in

the forum in the display and evaluation, as shown in Fig. 5.

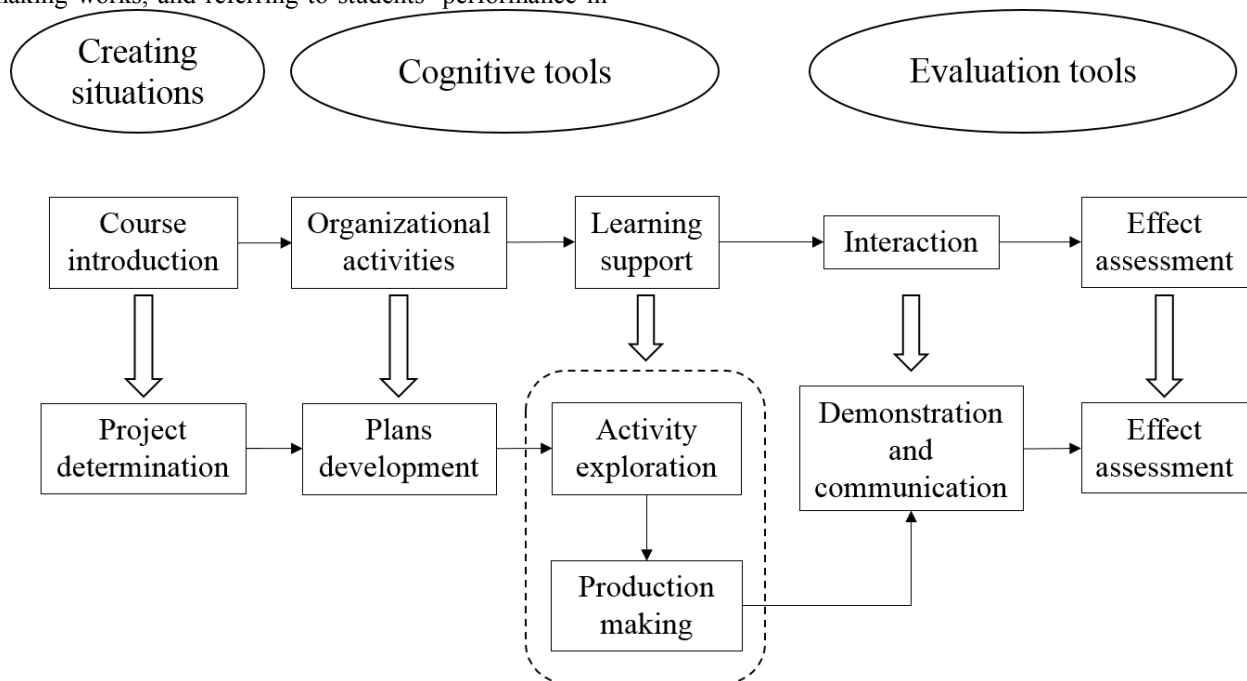


Figure 5. PBL design based on blended learning.

C. The Advantages and Disadvantages of Blended Learning

Klotz's study found that blended learning significantly reduced the amount of time spent on teaching in the classroom and made students perform better while enjoy the whole process. Similar findings appeared in the paper by Samuel Riffell *et al.* who also believe that the effect of blended learning teaching model is equal to or better than that of the traditional teaching model. [26] Many Chinese studies also found that blended learning is conducive to improving students' scientific knowledge and improving the performance of traditional examinations. Lin Xiaofan and others summarized the advantages of blended mobile learning as Fig. 6, [27] in which the advantages of online learning can be summarized as follows: (1) it is rich in resources which are easy to access; (2) it can improve students' participation and attention; (3) the interaction between teachers and students is more flexible and more timely; (4) it helps the students to individualize their learning. The advantages of offline learning can also be summarized as four points: (1) real experimental items can be provided; (2) unified answers to common questions can be provided to save time; (3) it can promote more efficient, more in-depth face-to-face communication, and cultivate the feelings of teachers and students; (4) a teacher can help individual students who need them individually. Therefore, according to this chart, blended learning can be considered as an effective way to integrate online and offline teaching advantages and promote students' learning in many aspects.

However, blended learning also has its shortcomings, mainly in the following three points: (1) The overemphasis on the main role of the students leads to the unclear position of the teacher's role. [28] The new curriculum reform emphasize the teaching process should be teacher-led, student-centered and be completed by both teacher and students. But the special learning style of blended learning invisibly led to the excessive manifestation of the main role of students, and weakened the leading role of teachers. Students in the learning process who lack the necessary guidance and help are easy to feel lonely and helpless, so as to produce the psychology of weariness, resulting in a decline in the quality of learning. (2) The excessive pursuit of the amount of resources and ignoring the effectiveness of resources increase the cognitive load on students. In order to promote personalized learning, blended Learning often provide students with a lot of resources, which creates psychological stress and learning burdens for many students. Because students need to spend a lot of time learning which resources are most suitable for their own learning and in which way or with which resources they can learn the knowledge most effectively. (3) Too much emphasis on the design of online resources entails ignoring the development of offline activities. Literature study found that many studies were concerned about the production of micro-class, the platform design, etc., while in the design of blended learning, they talked few about offline activities. And the mentioned offline activities are carried out by some basis methods like teacher explaining or team cooperation, with no pertinent cooperation with blended learning.

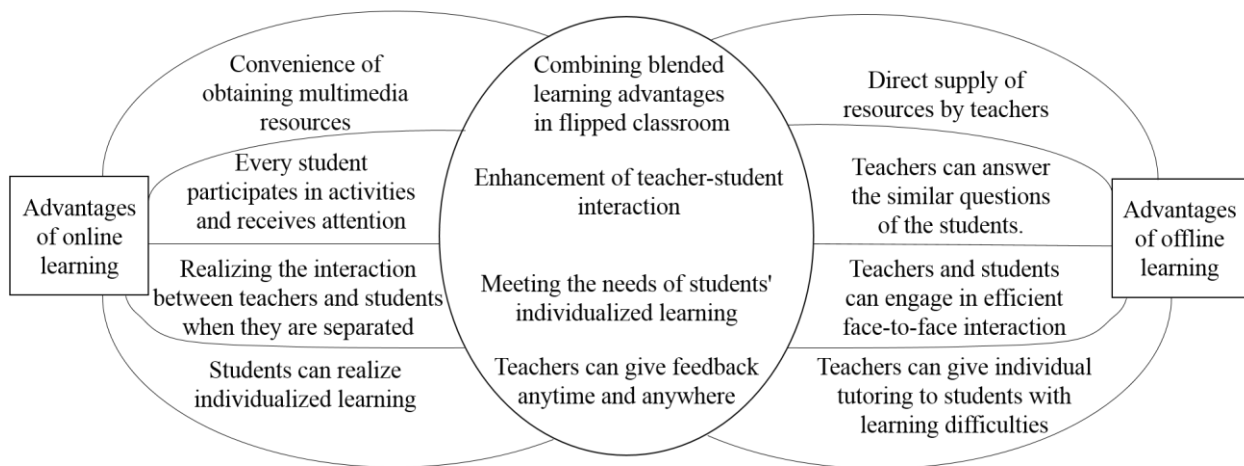


Figure 6. Advantages of blended mobile learning.

In view of the above analysis, this study will take full advantage of its advantages in the design of activities and try to make up for its deficiencies. For example, when we design an activity, the first is to delete the redundant online resources. And secondly, we must seriously think of the cooperation of online resources and offline activities and try to make them cooperate with each other and strive to achieve the complementary advantages of the two. In the implementation process we should also pay attention to play the leading role of teachers to provide timely help and guidance to students.

IV. DEEP LEARNING

Chinese traditional education emphasizes the importance of specific knowledge unilaterally and lacks the integration of knowledge, thus separating the theoretical knowledge from the actual situation, resulting in the students failing to apply their skills and lacking the ability to solve problems. In addition, with the development and popularization of information technology in the field of education, this shallow learning brought by digital reading is full of daily life. For the primary and secondary students nowadays, this kind of shallow learning affects their way of thinking. Over time, their critical thinking skills and ability to migrate will be weakened. However, the era of knowledge economy means that knowledge is no longer the predecessors' words, but the product of each subject's deep processing of objects. And the poor critical thinking ability and transfer and applying capacity directly affects the output of creative knowledge. Therefore, deep learning that corresponds to the shallow learning has drawn increasing attention. In the 2015 Horizon Report (Basic Education Edition), project-based learning is considered as a typical deep learning method. Then in 2016, Thys, Miranda *et al.* took that whether the students had happened deep learning as one of the 15 aspects to evaluate the effect of PBL teaching. [29]

A. The Connotation of Deep Learning

In China, deep learning was proposed by Professor Rigga in 2005. [30] This concept was originally proposed by American scholars Ference Marton and Roger Saljo in 1976, contrasting to the shallow learning of mechanically and passively receiving knowledge and storing information in isolation. Biggs, Pask, Entwistle and Ramsden, scholars of the same period as Ference Marton and Roger Saljo, also studied the learning process and learning outcomes of students and found two different learning methods, shallow learning and deep learning. Du Juan and other scholars compared deep learning and shallow learning from many angles in their papers, and summed up the differences between the two as Table II.

Thus, shallow learning is the memory and understanding of simple knowledge, which is the basis of deep learning. Deep learning is based on shallow learning, which is a meaningful and active learning that students use a variety of learning tools to construct, transfer and apply knowledge. The goal of deep learning is to improve learners' higher-order capabilities of problem solving, higher-order thinking, autonomous learning, knowledge innovation and so on.

B. The Process Model of Deep Learning

The desire for deep learning has led researchers to begin exploring ways to achieve deep learning. Henri splits the learning process and emphasizes five aspects of participation, interaction, sociality, cognition and metacognition in the learning process. Then Oliver and McLoughlin recast and integrate the above five aspects and put forward five types of interaction in the learning process: social interaction, procedural interaction, explanatory interaction, interpretive interaction and cognitive interaction. Du Jianxia *et al.*, from Mississippi State University in the United States, further summarized the five types of interaction into three processes of information, method and cognition, and further established a deep learning framework in distance education as shown in the Fig. 7.

The framework does not exclude shallow learning, instead, it regards shallow learning as the basis for deep learning, mainly in the first phase of memory of knowledge and information. The second phase is the stage of transition of knowledge to skills, in which phase learners practice and reflect repeatedly, sorting out their thinking and deepening their understanding in this process. The last phase is the stage of solving the problem, that is, forming a strategy. At this stage, learners need to put forward strategies to solve problems based on deep understanding of what they have learned, stimulate creativity, and constantly improve their strategies in the process of being questioned. The model is clear and conforms to the learning process of students, but this model ignores the promotion of evaluation in student learning.

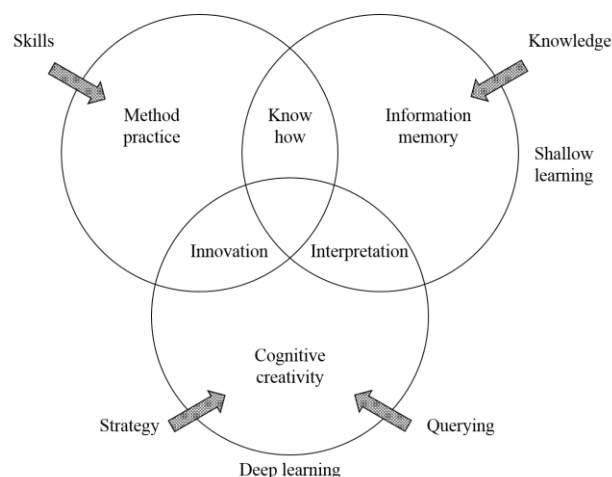


Figure 7. A deep learning framework in distance education.

TABLE II. THE DIFFERENCES BETWEEN DEEP LEARNING AND SHALLOW LEARNING SUMMED UP BY DU JUAN AND OTHER SCHOLARS

Items compared	Deep learning	Shallow learning
Theoretical basis	Constructivism learning theory, distributed cognitive learning theory, situated cognition and learning, metacognitive learning theory	Objectivism learning theory, behaviorist learning theory
Learning target	Concerned about the development of high-order thinking ability of learners	Focus on the basic knowledge and basic skills of the learners, usually the acquisition of low - order thinking.
Learning form	Deep processing, deep understanding and long-term preservation; knowledge construction, transfer application and problem solving	Passive acceptance, simple repetition and mechanical memory
Learning knowledge system	Old and new knowledge linked, multidisciplinary integrated, complex problems as the main line, to master deep-seated knowledge and other unstructured learning content	Structured units made up of single discipline, scattered, simple, isolated and unrelated facts, and superficial problem or concept
Focus	Focus on the core knowledge needed to solve complex problems and the development of learners' metacognition	Focus on the basic knowledge and skills needed to solve the shallow problems
Learning motivation	The inner needs of the learner to satisfy the needs of the fun of knowledge	Mainly to adapt to the external pressure of non-own needs
Involvement	Active learning	Passive cognition
Learning environment	Technology-rich learning resources and learning tools	The learning resources are relatively simple and poor
Self-command	Self-directed	Reproducing the learning content according to the requirements of the course or the teacher's request
Learning organization forms	Individual inquiry, collaboration and interaction	With collective, unified planning
Thinking level	Higher-order thinking (such as innovation ability, problem solving ability, decision-making power and critical thinking ability)	Low-order thinking (such as knowing, remembering, reciting)
Roles and relationships between teachers and students	The teacher is the chief of equality, the designer of the curriculum, the organizer of the activity, the guide of the learning; the student is the individual that can fully display the self.	The teacher is the command while the student is the audience
Learning effectiveness	Good effect, but efficiency may be low	High efficiency, but the effect may not be good
Information technology application	As a learning tool (cognitive tools, collaboration tools, inquiry tools)—use technology to learn	As a tool for assisting teaching (to play and demo)—learn from technology
Transfer ability	Flexibly use the learned knowledge and ability to transfer it to practice and solve practical problems	Only to solve problems mechanically, not to synthesize, and to use the learned knowledge flexibly
Evaluation method	Learning contract, evaluation gauge, qualitative evaluation, process evaluation	Quantitative evaluation, summative evaluation
Reflection state	Step by step understanding, critical thinking, self-reflection	Lack of reflection in the process of learning

American scholars Eric and Leann made up for this regret in *Deeper Learning: 7 Powerful Strategies for In-Depth and Longer-Lasting Learning*. They put some strategies, which contribute to the implement and promotion of deep learning, into the process of deep learning and proposed a deep learning process model

called “the Deeper Learning Cycle (DELIC)”, as shown in Fig. 8. This model is based on the perspective of teachers' teaching and aims at promoting learners' deep learning, of which “deep processing knowledge” is the most critical stage. Teachers should guide the students to carry out fine and effective processing of the new knowledge acquired,

developing their abilities from knowing, analysing to colligating, applying and assimilating. Meanwhile, they need to guide students to evaluate their own learning and

help students to correct and adjust their knowledge through timely and accurate learning feedback.

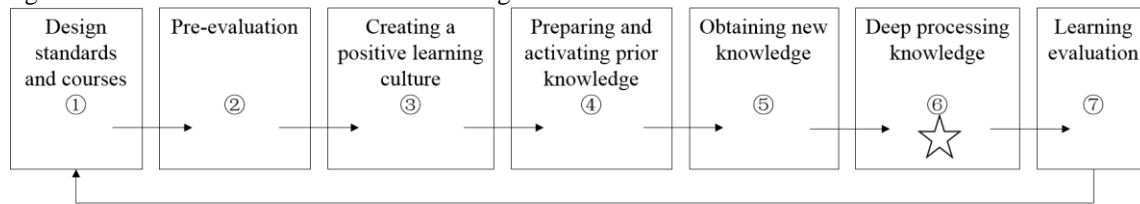


Figure 8. The Deeper Learning Cycle (DELIC).

Nelson Laird and others divided the process of deep learning from different perspectives. They thought that deep learning can be divided into three interrelated parts: high-order learning, integrated learning and reflective learning, of which the reflective ability is an important high-order thinking skill that is valued by learners both in high-order learning and in integrated learning. Therefore,

among the three forms of deep learning, reflective learning is a relatively more important form for the realization of deep learning. Based on the DELIC deep learning model proposed by Eric and Leann, emphasizing the importance of reflection, this study designs the corresponding curriculum according to the process model shown in the Fig. 9.

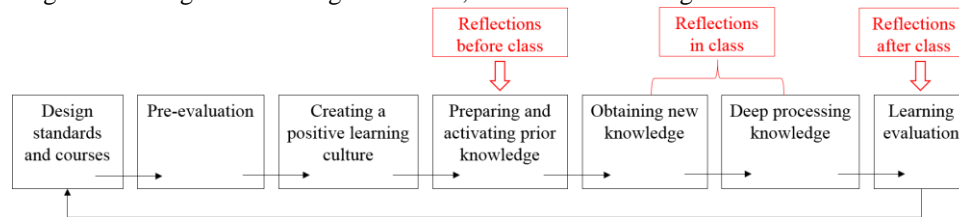


Figure 9. The process model of deep learning this study used to design the corresponding curriculum.

V. DISCUSSION AND CONCLUSIONS

After defining the specific content and key steps of PBL, blended learning and deep learning, it can be seen that there is a clear correlation among the three, as shown in the Fig. 10. In the environment of advocating blended learning, PBL can be implemented to promote students' deep learning.

When implementing a specific course, we also need to define what resources are required for each of the key PBL steps. With such problems, the author went to many

primary and secondary schools in Ningbo and Shanghai to conduct field research. Through interviews with students and teachers, the author comes to the conclusion that teachers often use online resources in two areas, which are pre-class introduction and after-school expansion. In addition, students like to learn by watching video, and both teachers and students have a higher enthusiasm for outdoor classes. Combined with the cases mentioned above, the author initially proposed the model shown in Fig. 11.

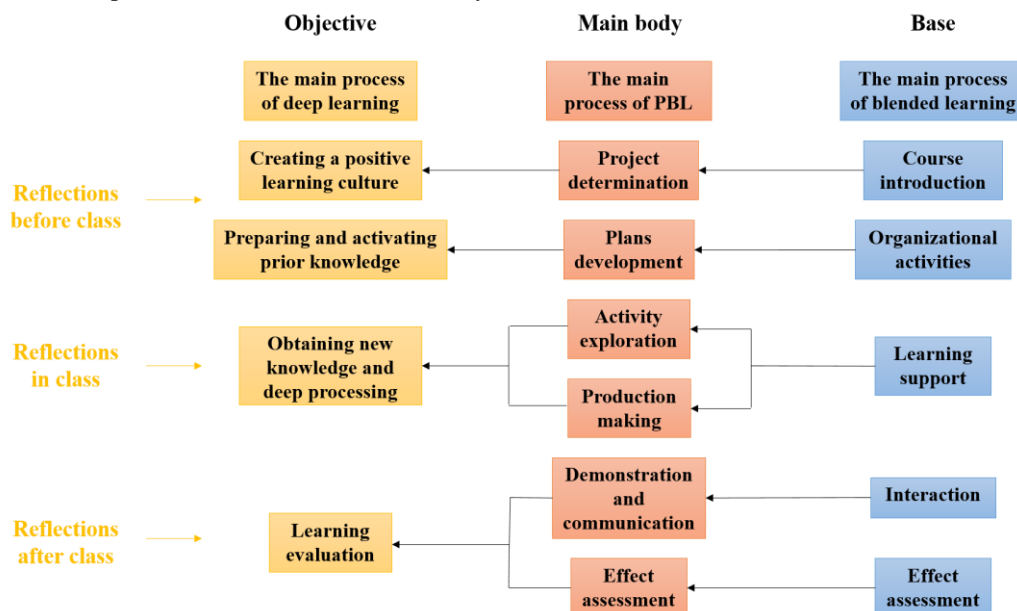


Figure 10. The correlation among PBL, blended learning and deep learning

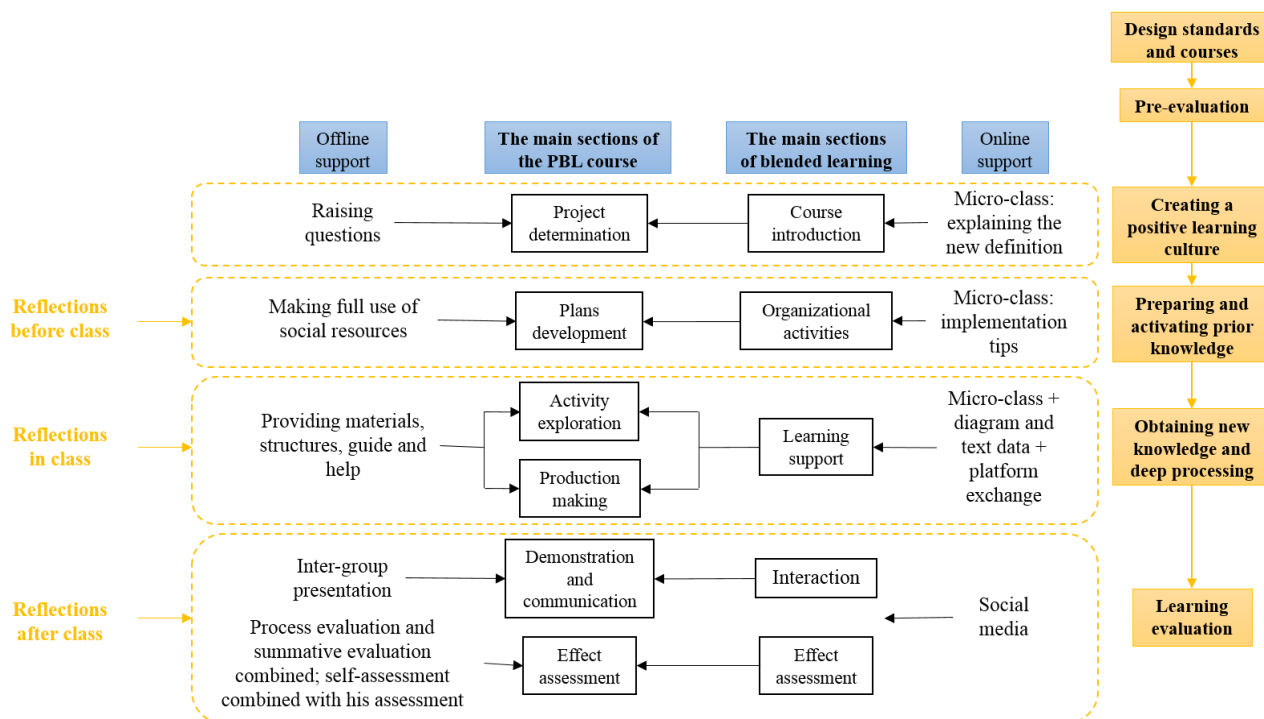


Figure 11. The model of PBL curriculum, designed based on blended learning to promote students' deep learning.

It is important to emphasize that because the subject of the course is PBL, the course content should be as socially relevant as possible. Therefore, the author thinks we should make full use of social resources in raising questions and making plans, combine actual knowledge with social reality to determine the real project and formulate an implementable plan. For PBL, activity exploration and production are the core of the course. In these two aspects, not only the support of various forms of online resources is required, but also the teachers are required to provide learning support for students and participate in the process of constructing students' knowledge. Meanwhile, the teachers need to grasp the dynamics of students and course progress through the network platform and offline interaction. In the session of displaying and communicating and effectiveness evaluation, if time is sufficient, we can use the internet to expand the students' exchange platform, comprehensive referencing social evaluation. If the class time is limited, we need to give students the opportunity to communicate and demonstrate in the class, and adopt a variety of evaluation methods. Finally, it should be stressed that reflection is an effective way to promote students' deep learning. Therefore, students should be encouraged to reflect timely before class, in class and after class to improve their learning effectiveness through recall, display and evaluating respectively.

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