# The Comparison of Problem-based Learning (PmBL) Model and Project-based Learning (PtBL) Model

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*Abstract* - **Along with the growth of ICT application, the roles of teachers and students are changing from knowledge provider and acceptors to knowledge sharing and problem-solving. In this sense, problem-based learning (PmBL) and Project-based learning (PtBL) are incorporated into educational settings gradually to enhance the opportunities and mechanism of knowledge sharing. Nevertheless, there is confusion existed in operating PtBL as PmBL in engineering education. Therefore, this article is to extract the differences between PmBL and PtBL in their theory and practice to ensure the operation of the two learning approaches are at the right command. Then, the learning effectiveness of students involved in the two approaches will be promoted at the most.**

## INTRODUCTION

There are various definitions of creativity; however, there is commonness according to Osche that creativity can bring something into being that in original (new, unusual, novel, unexpected) and also valuable (useful, good, adaptive, approbate)(Osche, 1990). Nevertheless, the creativity of students decreases with age (Torrance, 1962). That's because the education stresses too much on the memorizing and understanding of knowledge instead of applying and reasoning (Guildford, 1981). In another word, if problem-discovering and problem-solving activities are missing in education, the creativity of students can not be stimulated (Cropley, 2001).

With the development of technology, students' learning method has switched from practicing on blackboard to the internet and the learning goal for students has also changed from knowledge-absorber to problem-solver (Hong, 2005). Basically, with the change of time and the application of technology, education can be divided into several phases: (1) In terms of the development of hardware technology: (a.) batch, (b) timeshare, (c) pc, (d) workstation, and (e) notebook. (2) In terms of the development of software technology: (a) system software, (b) personal software, and (c) internet software. With the development of technology, education technology can also be divided into different developing phases: (1) Before computer technology: (a) blackboard, (b) project slide, (c) photocopy, and (d) video tape phases. (2) After the popularization of computer: (a) combing of TV and computer, (b) multi-media, and (c) internet application phases. The role of the teacher has switched from "lecturer" to (1) knowledge expresser, (2) instructor and (3) companion of the learner. The role of the student has turned from "listener" to (1) observer, (2) performer and (3) peer learner. The interaction between the teacher and the student has changed as well. The student has turned from "knowledge-memorizer" to (1) information-processor, (2) analyst/ critic and (3) problem-solver. In another word, the student has turned from "correct answer-finder" to (1) principle-applicant, (2) knowledge-synthesizer and (3) knowledge-creator.

To speak more concretely, the teacher and the student become learning partners. The student will not become a knowledge-creator, only if the teacher cultivates the student with the followings (Cropley, 2001): (1) to experience various ways of thinking, (2) general knowledge, (3) expertise on problem-solving, (4) analyzing and inducing techniques, (5) the ability to learn by analogy, (6) the ability to turn knowledge into practical use, (7) the ability to affirm problems based on the above statement, we know that both problem-based learning and project-based learning are gradually adopted in the educational environment. However, they are both called for short as PBL; some conditions are not clarified thus desirable results are not achieved after practicing. This paper will discuss about the goals, operational ways, learning processes and evaluation methods of both PBLs; hopefully to increase the performance of PBL application.

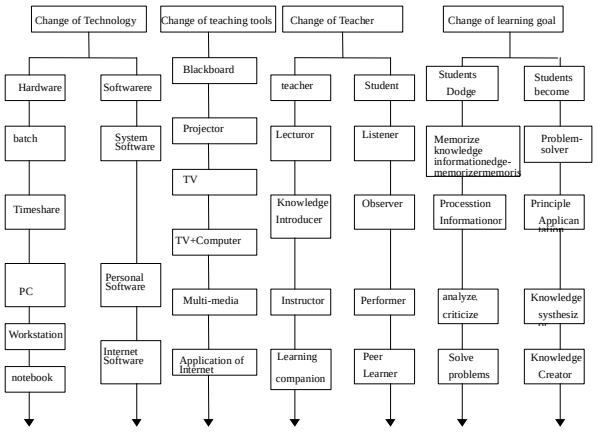


FIGURE 1.

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THE CHANGE OF THE ROLES OF THE TEACHER AND THE STUDENT AND THE LEARNING GOAL

And (8) the ability to design, control schedule and improve personal learning plan. There are ways under current teaching model can generate these eight abilities, such as: situated learning, problem-based learning and project-based learning.

## GOALS OF PBL

Problem-based learning (will be referred as $P_m$BL in this paper) emerged in medical colleges in early 1960s. Until 1990, around 40% of the medical schools adopted PBL (Hendry and Murphy, 1995). Around 50％ of engineering colleges in the United States have adopted PBL while teaching (Abman & Lopez, 2000). And project-based learning (will be referred as $P_t$BL in this paper) is generally applied in the engineering field. The two PBLs have a lot in common on concepts and practicing; thus, confusions among general public are often occurred. Therefore, this paper will discuss about the similarities and differences of $P_m$BL and $P_t$BL.

Biggs (2000) pointed out that both PBLs have the quality of high participation from the student; therefore, they generate higher knowledge value through learning. Biggs (2000) divided knowledge values through learning into: (1) knowledge memorizing, (2) knowledge understanding, (3) knowledge application, (4) knowledge reasoning, (5) knowledge creation and (6) theory construction. More likely two PBLs can generate values of knowledge application, reasoning and creation. Barrows (1986) classified the student-led teaching methods that used to be led by the teacher into: (1) lecture, (2) case comment, (3) case study, (4) project design and (5) problem-based teaching method. Case comment and case study both focus on the case experience for the student to learn; however, case comment works with fixed text cases while the student has to look for cases to be discussed in class as case study and find solutions. Both $P_t$BL and $P_m$BL comprise lecture, comment and case study. They both emphasize on student-centered study (Torp & Sage, 2002). See Chart 2 below:

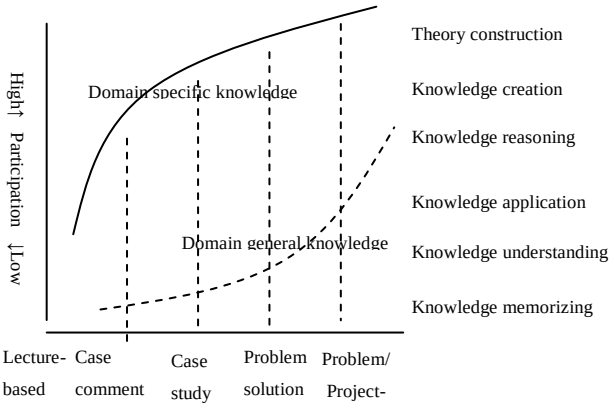


CHART 2.
THE INFLUENCE OF TEACHING METHOD AND PARTICIPATION TO KNOWLEDGE DEVELOPMENT

Biggs (2000) believed PBL is valued for the following reasons: (1) the teacher and the student who were exposed to PBL all recognize it's more interesting than the traditional method. (2) PBL learners perform better in the working field after graduation than traditional learners. (3) The student enjoys self-learning and can share with a group to increase knowledge. In fact, from Biggs's notion, we can understand PBL better through the theory constructed by him. Different teaching methods have a lot to do with the increase of professional knowledge and non-professional knowledge. The application of PBL allows the highly participating student to generate the most knowledge value. Its knowledge values include: knowledge memorizing, knowledge understanding, knowledge application, knowledge reasoning, knowledge creation and theory construction.

For example, let the children around the world to measure the boiling temperature for water. Because of the different altitude, the boiling point is different; the relationship between pressure and boiling point is therefore concluded. Also, different components in the water affect the boiling point, children around the world can analyze and provide data for them to discover the commonness around the world and form a theory. This educational process can be called $P_t$BL. In terms of knowledge value, $P_t$BL not only comprises procedural knowledge application, but also provides the value of theory construction for the student who came up with a theory. Here is another example, there were less lotus blossoms in the lotus pond next to National Museum of History the past summer, students can discuss the situation from the change of water quality and the reasons behind, such as: the change of temperature, lives in the pond (algae, fish)…etc. to determine the major factor behind the change. This is problem analysis in $P_m$BL, the more knowledge reasoning, the more accurate we can find out the cause of the problem. If an ecological theory can be formed later, more knowledge value is seen here. Tiong et al. (2004) proposed the following goals for PBL: (1) Application creation and critical thinking, (2) Improving communication skills, (3) Enhancing cooperative learning ability, (4) Developing the ability to explore oneself and be responsible for oneself, (5) Enhancing the ability to apply and look for knowledge and (6) Enhancing the planning and controlling ability for students.

## OPERATIONAL MODELS FOR TWO PBL

According to the above description of the goals and basic concepts of PBL, we come to an understanding that the design of PBL is based on the practical and theoretical needs to motivate learners and guide them to understand, apply and create knowledge; furthermore, learners can understand knowledge or construct new models through experience passing, case study or knowledge sharing. The PBL model is designed shown as Chart 3.

In the process of the development of the PBL course, new knowledge, idea and model are come up by teachers and knowledge is later transferred through the following three ways: (1) Understanding knowledge through the passing down of experience from teachers to students, (2) Constructing knowledge through the peer knowledge

sharing, and (3) Verifying knowledge through case study and project completion. Through the above processes, students have new knowledge understanding, reasoning, applying and creation. Here, PBL course design is completed coving theoretical and practical needs.

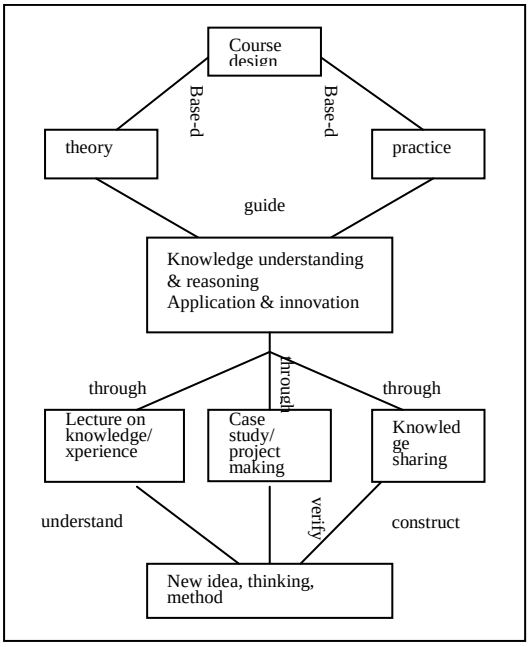


FIGURE 3.
TWO DEVELOPMENT MODEL OF PBL

To correspond to the above operational model of PBL, the basic operational steps of PmBL must include: (1) Use of professional knowledge, (2) Situation design, (3) Learning and knowledge reasoning and (4) Evaluation. The relationship is further explained in Chart 4 below:

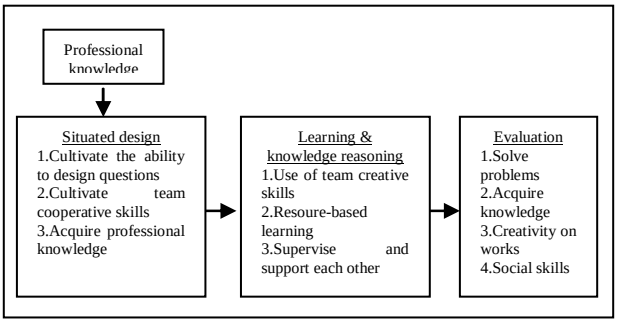


FIGURE 4.
THE BASIC OPERATIONAL STRUCTURE OF $P_M$BL
SOURCE: (BIGGS, 2000)

In the basic operational structure of $P_m$BL, teachers will design text based on designated professional knowledge field to cultivate students' ability to design problems and to acquire professional knowledge through the use team cooperative skills. In the process of learning and knowledge reasoning, students will get familiar with team creative skills and make most use of resources and at the same time supervise and support the others; while in the process of evaluation, students will discover problems, acquire knowledge and gain thinking and social skills.

The basic operational steps of $P_t$BL include: (1) Use of professional knowledge, (2) Project design, (3) Learning and knowledge reasoning and (4) Evaluation. The relationship is further explained in Chart 5 below:

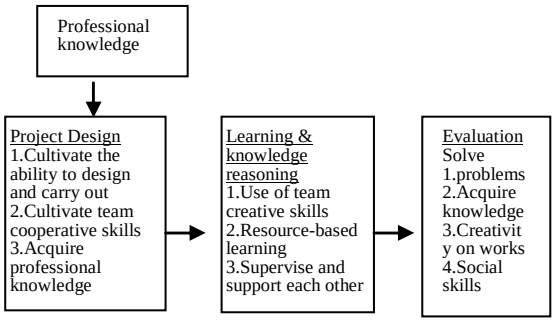


FIGURE 5.
THE BASIC OPERATIONAL STRUCTURE OF $P_T$BL

The biggest difference of the basic operational structures of $P_t$BL and $P_m$BL is project design in phase two. $P_t$BL stresses on the cultivation of students' ability to design and carry out. In the process of evaluation, it focuses on problem-solving and creativity on works. Basically, $P_m$BL throws problems at students, so they can learn through group discussions and discuss with teachers later and finally share with other groups, while $P_t$Bl wants students to solve the already known problems and to further finish the projects.

## PRECONDITIONS FOR PBL

Hong (2005) believes that there are four operational models for PBL:

Model 1 : students' self-learning → group discussion → discussion with teachers → another group discussion → group discussions among the whole class

Model 2 : students' self-learning → group discussion → discussion with teachers → students' self-learning → another group discussion→ group discussions among the whole class

Model 3 : group discussion→ students' self-learning→ group discussion→ discussion with teachers→ group discussions among the whole class

Model 4 : group discussion→ discussion with teachers→ students' self-learning → group discussion → group discussions among the whole class

Different models are applied depending on the levels of students and problems. Savin-Baden (2000) raised several preconditions for applying PBL: 1) Focus on improving of cognitive skills, 2) Instead of training on knowledge memory, the course is valued and problems are seen as the core.3) PBL works better in smaller groups, 4) Theory and practice are both covered in the course, 5) The role of the teacher is a catalyst, and 6) Evaluation will be evaluated by

peer learners instead of the teacher. (Except for knowledge test)

Preconditions for $P_m$BL: with (1) ill-structured problems, (2) real-world connection problems and (3) multi-fields knowledge. Only when these preconditions are met, students will be interested in learning and learning effectively.

Preconditions for $P_t$BL: with (1) testable prediction, (2) available or easily accessible materials, (3) knowledge that's complex enough and (4) multiple solutions that can be generated.

### PBL PRACTICE PROCEDURES

**(i.) $P_m$BL practice procedures:**

The teacher gives students a problem for them to solve, and they can learn more through this process. The question is usually hidden in a play script or case study and it's simulated to complicated real life problem. There is no fixed final work required to present in $P_m$BL. "A problem" and "the motivation to solve it" are the main forces behind. $P_m$BL allows students to (1) define the problem clearly, (2) develop hypothesis, (3) collect data and (4) prepare for the clear designated answer. Other designs connect students to the cases, among which some may not have answers, for these cases are designed to increase students' learning interest and to collect data from. $P_m$BL practice procedures are as follow:1)Students' doubts arise from problems, 2)Students study ahead on problems, 3)Raise additional questions4)Define the coverage of knowledge, 5)Propose a plan to get more information,6)Conduct necessary researches, 7)Share and conclude their new knowledge., and 8)Make their conclusion.

**(ii.) $P_t$BL practice procedures:**

The teacher gives students a problem for them to solve, and they are told to hand in a final project with special knowledge, content or skills in it. Students can use their own ideas to introduce this final project and to further reflect activities in the real world and to complete the upcoming mission with their ideas and methods they know. From this, we can see the final project plays an important role in $P_t$BL. More importantly, students acquire sufficient knowledge and skills through the process of making the final project. $P_t$BL practice procedures are as follow:(1)Identify the creative final project, (2)Ensure the target audience,(3)Explore the connotation of the project,(4)Design on the project,(5)Make a schedule for the project,( 6)Begin to work on the project,(7)Solve the problems and disputes, and( 8)Complete the project.

### LEARNING QUALITIES OF PBL

PBL for applying skills (Tiong, Netlo-Shek, & Agnes, 2004) : 1)Increase implicit learning motivations,2)Cultivate explorative and open attitude,3)Cultivate independent or cooperative problem-solving attitude,and4)Build up confidence through the completion of the project.

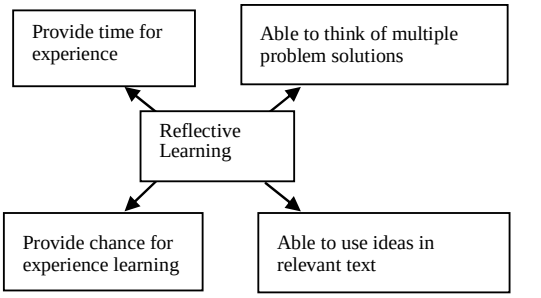


FIGURE 6.
REFLECTIVE LEARNING IN PBL
SOURCE: (SIANG, 2004)

In Chart 6, the teacher provides time for students to experience and that is the result of scaffolding learning. In PBL, scaffolding can be provided or taught by teachers or peers (Bull et al., 1999). The most important part among this teaching-each-other process is for students to turn new information into constructing their own knowledge. Therefore, Bull et al. (1999) believes scaffolding is: 1)To assist learners to bridge the known and unknown.2)To assist learners to develop meta-cognitive ability.3)To assist learners to re-construct knowledge structure and to internalize it.4)To assist learners to have better time arrangement and project planning.5)To assist learners to evaluate on the fruitful result or progress.

Both Bull et al. (1999) and Greening (1998) raised some scaffolding strategies for PBL: 1) To assist students to overcome the difficulties while gaining knowledge, 2) To assist students to divide assignment into smaller ones to complete, 3) To remind students not to ignore some important parts (such as using contrasts), 4) To provide students proper procedures to affirm problems and to solve them, and 5) To provide examples for students to follow.

Kaartinen & Kumpluainen (2002) raised the orders for different scaffolding strategies. From top to bottom strategies are as follow: 1) to provide ways or skills to divergent or convergent thinking. 2) To describe the status quo of the question. 3) To provide tools to diagnose or to solve problems. 4) To provide examples.5) to provide results.6) to provide explanations (cause and effect).and 7) to provide evidences.

### THE PBL PROCESS

The process of $P_t$BL is a complicated one, it takes the integration of concepts, knowledge and skills to complete the project work (Atkinson, 2000). To speak in another word, innovation process is constructed by many innovative activities (such as: new ideas, evaluations…etc.) (Amabile, 1996; Shalley, Zhou, & Oldman, 2004; Stein, 1967).

The $P_m$BL process :

(1) Interpreting scenario
(2) Brainstorming
(3) Framing the needs of learning
(4) Having self-based learning
(5) Diagnostic meeting

The $P_t$BL process

(1) Constructing ideas : 1) Goal: to understand the requirements of the production. 2) Activity: a) Communicating: with team members on the function and shape, and b) Taking notes: to classify data. 3) Mentality: a) Knowledge: application of technology and physics knowledge, and b) Thinking: divergent thinking.

(2) Designing specifications : 1) Goal: setting the style and detail requirements for the production. 2) Activity: a) Communicating: with team members on the function and shape, b) Taking notes: drawing work chart and function sheet, and c) Preparing materials: according to the requirements of the production.3) Mentality: a) Knowledge: about the materials and manufacturing and, b) Thinking: convergent thinking

(3) Sampling : 1)Goal: completing the sampling of the production and find out problems .2)Activity: a) Processing: working together with group members on processing and putting together the materials, b) Communicating: discussing about the cooperation on processing and putting together the materials with group members or to find out problems and solutions ,and c) Taking notes: revising work chart .3)Mentality: a) Knowledge: the relationship between the processing way and the materials, and b) Thinking: reflective thinking.

(4) Adjusting and presenting the project work : 1) Goal: To adjust or re-make the piece of work into desirable condition. 2) Activity: a) Processing: working together with group members on processing and putting together the materials and to enhance functions, b) Communicating: discussing about the problems faced while processing, putting together the materials and enhancing functions with group members and find out the possible solutions, and c) Taking notes: on the problems needed to be solved or adjustments needed to be made. 3) Mentality: a) Knowledge: the understanding to the structure of the production and application and function of the materials, and b) Thinking: comparative, inductive, deductive and reflective thinking

Of course we see different ways of using two PBLs among different people. Basically, the strategies of $P_m$BL all begin with the discovering of a problem and to start the learning process from here (Boud & Feletti, 1997); while $P_t$BL begins the learning process from solving problems. PBL is not additional to the course but to have set problems in the course for students to solve, during the process of solving problems the attitude of knowledge-applying, self-management and knowledge-sharing can be cultivated. General PBL focuses on (Biggs, 2000):1)Problems we encounter in the real world : 1) Small to big problems that can increase the interactions among students .2) Constructing field knowledge through resource-based learning methods (for students). 3) Students are able to explain the knowledge .4) Students can apply acquired knowledge to solving problems. 5) Constant self-improving of students is the key for PBL to be a successful model .6) Developing the sharing skills of team knowledge

## CONCLUSION

Oakey (2002) wrote about the similarities and differences of two PBLs, both $P_t$BL and $P_m$BL are used to describe the scopes of educational strategies. They have similar definition in concepts, and because they share the same simplification of PBL, confusions are seen in some literature. Here the author states two PBLs' similarities and differences:

**Similarities of two PBLs:**

1. They are both teaching strategies and are expected to attract students effectively.
2. Both are reliable constructive learning methods.
3. Real world tasks are used in both to enhance the learning result. Real situations at work are simulated for students to have more than one solution or answer to the project and problem setting.
4. Both are student-centered problem-solving methods.
5. The teacher plays the role of a guide or instructor.
6. The student's role is to learn in a cooperative team for a long time and to explore the sources of multi-information.
7. While applying, there are two characteristics of $P_t$BL and $P_m$BL: (1) There is a very blur line between two PBLs. (2) They are both used in groups or competitions. They are complementary to each other.

**Differences of two PBLs:**

1. **Target:** $P_t$BL is considered as pro-K-12 education. Actually $P_m$BL is also used in K-12 education; however, it's originated from medical training or preparatory training to other professions (e.g. interns).
2. **"Final Project" is the core to the study:** (1) Project-based Learning ~ A final project is specially designed and well-processed. For example, computer-related projects require extensive planning and works to accomplish. A final project is used to carry out the plan, manufacture and process. (2) Problem-based Learning ~ A final project is simple and with more additions. For example. The presentation of a group's research discovery. The whole discussion and the process of research (to compare with the final project itself) are the major focuses of the whole learning process.
3. **"Problem Setting" is the core to the course:** (1) Project-based Learning ~ to work on the assumed project, the student will come up with various problems and try to solve through discussions. (2) Problem-based Learning ~ with clear, assigned problem, a thorough conclusion and a complete answer are required. In this direct feedback of answering the problem, problem setting is the core to the course.

On teaching design, $P_m$BL and $P_t$BL can be used in turns. Firstly, the teacher would design teaching plan according to real life problems. Students can collect information and discover problems through $P_m$BL method. Later, the teacher would develop the problems students explored on into teaching plan. Here students can solve the real problems through the project making. The process can be stated in the flowchart below:

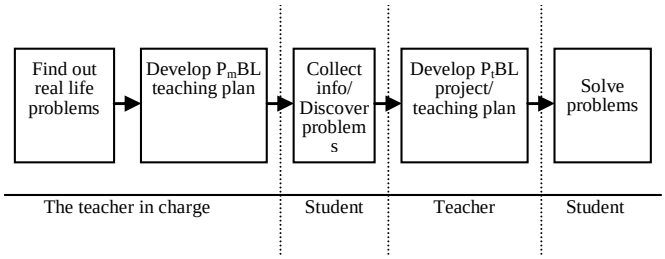


FIGURE 7.
THE FLOWCHART WHEN BOTH $P_M$BL AND $P_T$BL ARE APPLIED

In a word, PBL is based on situated learning and new ideas and concepts will be generated through the learner's personal effort and learning through team cooperation. Therefore, PBL is an effective interaction method in knowledge innovation. However, there are some conditions for a successful PBL application (Boud & Feletti, 1997):

1. Students with high morale. The more frustrations they encounter, the more persistent they become.
2. The change of the role of teachers (to instructors).
3. The change of evaluation methods.
4. Build up new ways or models of learning.
5. Problems encounter in the "real world" are used as teaching materials.
6. Students' learning condition is noticed, and guidance is provided when necessary.
7. Cultivate students with the learning attitude of "making a bold assumption and then verify it prudently."
8. Cultivate students with the ability of making the most use of resources.

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