The analysis of problem level and knowledge category in problem-based pedagogy applied to design education - to take office design as an example

Shau-Chou Yang
College of Technology, National Taiwan Normal University, Taiwan
sergio317@ntnu.edu.tw

Yu-Ting Ling[1]; Yi-Xin Zhang[2]

Abstract - **Upon the initial planning of interior design, there are always non-structural and blurry problems to deal with. In interior design filed, the application of problem-based learning (PBL) can efficiently enhance student's sense of accomplishment and problem-solving capability. Interior design includes dynamic and field-crossing problems to tackle. Therefore, it is extremely important if the teacher can utilize problem-based learning (PBL) to help students develop the ability to understand, analyze, solve and categorize various problems while conducting teaching.**
This research applies precisely experimental-design research method to investigate into the application effect of problem-based-learning teaching methods on college "Interior-Design" courses. The research begins with the method of "scenario" to induce problem-based circumstances and possible-designing conditions so as to help students find out the problems. In this way students can select the problems by themselves, learn actively and share knowledge interactively. Moreover, in terms of applied evaluation from students we could objectively find out the students' attitudes toward learning and their learning processes. As a result, the further improvement of teaching quality and standard ensures the possible maximum efficiency for both teachers and students.

INTRODUCTION

In multiple learning theories, problem-solving ability has been considered one of the nuclear ability needed to be cultivated. Problem-based learning (PBL) theory is an effective teaching method which cultivates problem-solving ability of students. As early as the 1970s, PBL has been used in medical education, and it also has been gradually used by various learning fields in recent few years. PBL is student-centered, and it allows students have more chances of active learning and applying self-build knowledge and abilities to solve problems; In other words, this pedagogy specially emphasizes on abilities of cultivating students to think and create independently, explore and research actively, and solve problems comprehensively.

Although the design usually solves design problems through ways of formulas, these formulas often create other problems when solving a problem. Designing policies and solving problems are always accompanied by many norms and criteria of poor definition even conflicting with each other, so the design always keeps in circles solving some arousing problems. In the other hand, the design process of practical operations does not follow a single framework to develop. But traditional courses are a framework of complete learning mode, so such knowledge structure and learning mode cannot integrate other knowledge. Students are unable to deal with multiple and complex design of related issues. Therefore, to the design field, traditional teaching methods may not reach requirements of professional design education in these following areas:

1. Design field includes multiple and cross-field issues. But in the traditional teaching, what teachers teach is structural knowledge--- one answer to a question. However, in the practical design, students must use cross-field knowledge, and present innovative solutions from many possible answers.

2. After graduation and entering career, the structural knowledge which students learned from schools maybe forgotten or out-of-date, and they must re-learn new knowledge. Therefore, how to cultivate students self-learning and constantly absorbing new knowledge is more important than teaching them structural knowledge in schools.

3. In the beginning of a plan, design questions are often non-structural and ambiguous issues. Therefore, in the process of teaching, how to train students the capacity of understanding and analyzing issues and summarizing is more important.

4. Answers of design questions are often without standard answers. Therefore, in the problem-solving process, we should train students to develop multiple thought and creativity, and the habit of respecting for different views with each other, analyzing rationally.

5. Modern design often requires teamwork to complete. Therefore, in school education process, we need to cultivate concepts of teamwork, learning and appreciating from each other.

[1]Yu-Ting Lin, College of Technology, National Taiwan Normal University,695700429@ntnu.edu.tw
[2]Yi-Xin Zhang , College of Technology, National Taiwan Normal University, 695700443@ntnu.edu.tw

The ultimate goal of Interior Design teaching is to enable students to creatively use knowledge they learned, and to truly solve the related issues of interior design cases in real world. Biggs (2000)'s study found: teachers and students who practically implement PBL teaching all agree that PBL is more interesting than traditional teaching. And the students who learn in PBL ways, their performance in career after graduation is also superior to those who receive traditional teaching. This study establishes a set of practicable teaching modes which integrate group teaching model and traditional project-based learning of interior design learning, and explores the possible effectiveness of this teaching model in interior design teaching. In brief, the purposes of this study include:

1. To understand the related theory of PBL and research and compile problem-based learning lesson plans of Interior Design.
2. To explore problem-based pedagogy, student's perception of questions in learning records of Interior Design.
3. To develop question analysis of Interior Design and knowledge analysis system.
4. To bring up the proposed PBL practicing model in interior design teaching.

The primary research question to be addressed in this paper is as follows:

1. How to manage the learning situation in PBL?
2. What kinds of" problem level" and "knowledge category" are students discussed of stage of problem analysis which can be study by students' learning process?
3. Using" problem level" and "knowledge category" analyze students' learning condition.
4. How to applied problem-based pedagogy to interior design education?

LITERATURE PROBING

1. The theory basis of problem-based learning

Problem-based learning (PBL) is a process that learners actively solve problems, and foster skills and abilities of solving real-world problems. So-called problem-based learning (Problem-based Learning, PBL) is the teaching strategies of learner-centered. Teachers design a real situation as a starting point of learning. Before giving learners any teaching, teachers demonstrate questions and let learners be in the process of actively problem-solving (S.F. Zhang 2001). This approach is the teaching activity of "learning to learn". The goal of problem-based learning is the ability to learn, not just to learning knowledge. (C.S Wu, 2002)In the problem-solving process, students control the entire progress of learning. They construct the related problem-solving knowledge, and then foster ability of self-directed lifelong learning and problem-solving skills, and ways of group cooperation. Therefore, PBL basically establishes on the basis of three learning theory, "cooperative learning", "situational learning", and "Constructivism". Its theoretical basis is as following:

(1) Cooperative learning: The main focus of cooperative learning is to use group cooperative learning to make learners achieve better learning outcomes, enhance creativity, learning responsibility, student's social skills, and communication skills (Johnson & Johnson 1989;Lebow,1993). Students are the center of teaching in the process of teaching. In ways of active cooperate learning, students replace teacher's teaching of one-way leading and then develop their team spirit (C.S. Zhang, 1997).

(2) Situated learning: learning should be an integral part of productive social practice. Learning is not passive, but a process of active acquisition. Through appropriate environment to build and guide students to control order, speed, and contents of learning by themselves and to interpret learning contents. Help them use what they've learned in future profession in their lives, or develop problem-solving abilities in real life skills. In other words, Situated Learning Theory emphasizes to provide learners "authentic learning contexts" to nimbly use learning results. Problem-based learning provides students with active learning in real world. In the progress-centered substantive activities, students gain opportunity to learn through personal and situated interaction, and develop self-guide and the ability to solve problems.

(3) Constructivism: In views of constructivism, learners actively construct meaning and bring their prior knowledge to adapt to the new situation (Y. M. Wu, 2002). In particular speaking, the knowledge theory of constructivism emphasizes the gaining of knowledge was only constructed by the individual .Learning is integration of new experiences, old knowledge, and old experiences. Learners constantly modify their original knowledge to assimilate and accommodate changes of external environment and achieve a balance. Problem-based learning emphasizes to learn from practice. In patterns of teamwork, students actively participate, discuss and discover problems with their peers. In the process of consultations and interaction, they construct and use knowledge to solve problems. This conforms to the learning theory of Constructivism.

2. The teaching model of Problem-based Learning

For the teaching model of problem-based learning, experts and scholars have different views, for example: Taba (1962) divided teaching units into eight steps, they are respectively: diagnosis needs, setting detailed goals, selecting contents, organizing contents, selecting learning experiences, organizing learning experiences, evaluation, checking balance and order; also like: Gustafson (1994) promoted models of teaching design: (a) Definition (identifying questions, analyzing environment, organizational management), (b) development (identifying aims, identifying ways, developing drafts), (c) evaluation (testing drafts, analyzing results, implementation/ recycling) (quoted from L.S. Li, 1997). To conclude, this study divides teaching design of problem-based learning into four stages: planning, design, implementation, and evaluation, as illustrated in figure 1. According to the Interior Design courses implementation of this study, such as PBL curriculum planning, PBL curriculum design, PBL curriculum implementation, and PBL curriculum evaluation, we explain them one by one:
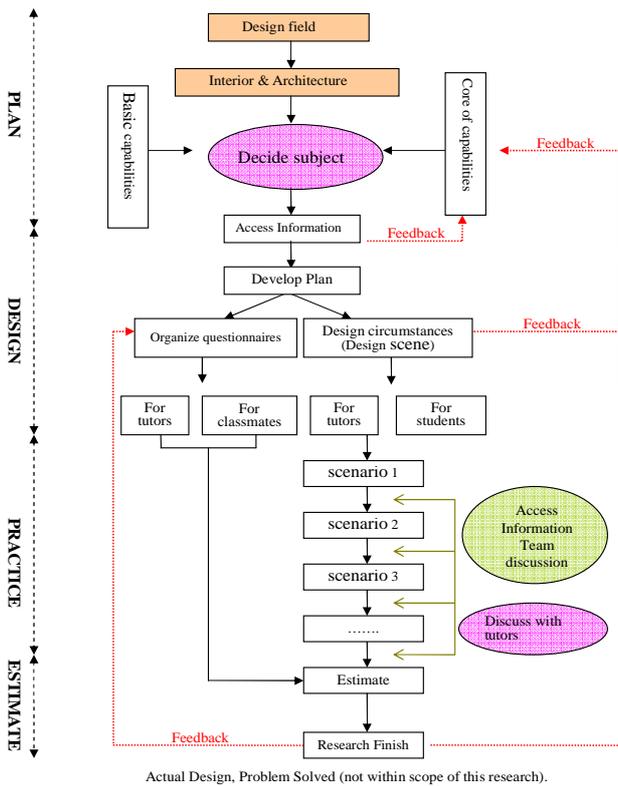
FIGURE 1
TEACHING DESIGN RESEARCH OF PROBLEM-BASED LEARNING

(1)Curriculum planning of PBL research

In PBL experimental teaching design, this Interior Design courses use the way of scenario (Situated Learning) to conduct situated problems and design conditions. Guiders (tutors) of each group implement monitoring, counseling, and assessment. In the progress of curriculum, tutors guide students to discover problems, and then students choose their own problems to voluntarily participate in learning, to share knowledge with peers, and to record learning files of each group. Tutors observe in the process and record the learning situation of students (As Fig.2).
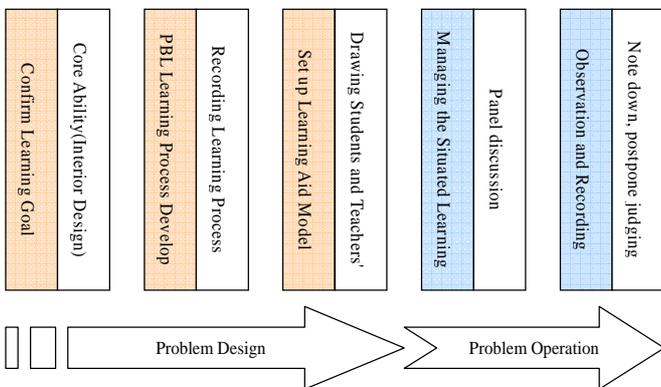
FIGURE 2
THE PLANNING FRAMEWORK OF PBL INTERIOR DESIGN CURRICULUM

(2)PBL curriculum design

"Office Design" is the theme of experiment courses; "PBL Problem-based teaching strategies" is the design basis of curriculum; the content of courses is "Office Design". According to Z.M. Xu's (1989) six major factors of Office Design: 1.OA Equipment 2.OA Furniture 3.Environment

4. Technology 5.Information 6.Human factors. After integrated and revised the six major factors which fit for our research, we presented six projects of learning abilities of Office Design, as illustrated in figure 3: 1) ambiance (about sense perception) 2) enterprise performance (displaying corporate images of enterprise), 3) human being (human considerations of software), 4) equipment (equipment and software user centered consideration) 5) function (functional space), 6) green (hardware greening). According to this, we developed four screens and through environmental guide of screens and tutor's question guiding to let students actively build the knowledge of "Office Design" they should learn and ideas of design thinking.

The outline of these four scenarios developed by this study are: scenario 1, explain office needs and human thinking of technological company; scenario 2, explain basic space needs and route planning; scenario 3, address considerations of space ambiance and the image of a company: and scenario 4, address further thinking of furniture design and ergonomics.

(3)PBL curriculum implementation

The curriculum design of this study is the curriculum framework which teachers and several tutors jointly planned (Figure 2). They set learning goals of the curriculum, arrange course schedule (Table1), and compile different scenario from different practical problems of life to use in different curriculum design.

TABLE 1
THE PLANNING TABLE OF PBL INTERIOR DESIGN RESEARCH COURSES

week	tutor	P.B.L. processes	Task	PBL
1	theme decisions	Select problem What the problem we are trying to solve	To analyses the program (site 、 user 、 case study)	Problem based learning
2	Problems analysis select direction of problems discussion	Develop a scenario	To develop the concept of plan To make design principle	
3	Group discussion - group report	Develop a list of problem	To analyses the concept of plan To make design principle To develop the concept of form	Pt+Pm
4	Group discussion - group report	Brainstorming Summarize 、 criteria 、 constraint	To make some feasible projects	

				Project based learning
5	Develop Idea - develop drafts	Brainstorming Office planning 、 challenge	To assess for the case the projects To develop the unit of space	
6	Group discussion - graphic design	Office composition Active participating encouraging Elaborating by team members	To assess for the case the projects To develop the unit of space	
7	Group discussion - Facade Design	Design completeness 、 practicality Overall feeling	To develop the unit of space To think about materials and detail	
8	Group discussion - design expression	Communication and presentation	To make a decision and presentation	
9	Group discussion - expression of design	Result and creativity	The develop the team assignments	
10	Assess sketches - results assessment, teachers assessment	Evaluation checklist	To present the assignments	

Subjects were junior of National Taiwan Normal University who major in this interior design curriculum. There were 5-6 students in every group, and direction by three tutors. This study focus on content analysis of students' learning process files. Final work and final presentation were not within scope of this study.

(4)During PBL problem induction, we may managing the situated learning and assess the level of student understanding from questions raised by students in order to propose more in-depth inductions. Through problem proposition during the teaching and learning process, students are guided through thinking and reflective thinking. New information is further collected and applied. In the following, tutors are going to propose different levels of inductive questions based on cognitive level:

a. Probes ask students to go deeper into an idea or concept, such as: Can you say more about that?
b. Challenges prompt students to support their claims or validate their reasoning, such as: How do you know, that to be true?
c. Redirects bring students back to the problem, such as: Before our discussion you said _____; what do you think now, Jennifer?
d. Goal-setting prompts help students set goals for their inquiry and solutions, such as: where do you think we can find out that information?
e. Monitors encourage students to monitor their inquiry and problem-solving processes, such as: Do you have everything you need to report out in you group?

DATA ANALYSIS AND DISCUSSION

1. Data collection

This Interior Design research courses proceed in PBL. The progress of the teaching can be referred curriculum tables (Table1) and the contents of experimental teaching courses. By collecting analytic data, students build knowledge and have the use of multiple knowledge. In the knowledge field of office space, students gain diverse and multi-dimensional learning (as Fig.3). It makes students have entirely and limitless learning in the professional knowledge contents, and then learns how to use PBL spirit. Students can choose the most interesting or the first areas to learn, and have self-learning initiative.

In PBL experimental teaching design, this Interior Design courses use the way of "scenario" (Situated Teaching) to conduct environmental problems and design conditions. Guiders (tutors) of each group implement monitoring, counseling, and assessment. In the progress of curriculum, tutors guide students to discover problems, and then students choose their own problems to voluntarily participate in learning, to share knowledge with peers, and to record learning files of each group. Tutors observe in the process and record the learning situation of students.

The part of student evaluations is in ways of multiple evaluations. It mainly focuses on "process-oriented evaluation" and the final semester report of groups, and brings up specific book of design plans. The contents of the book are divided into two parts in accordance with problem-oriented and feature-oriented parts: the part of design of problem-oriented learning requires for the problems records of group discussion every time; in the part of design of feature-oriented learning, besides asking for explanation of design graph and concept, it asks for the draft of process development. It not only can trains students to develop abilities of pictures and words expression, but shows the learning progress records of students.

2. Problem levels

The problem levels are divided into three based on cognitive level. Usually initial problem level is "Cognitive-Level Question" that is some easy and base questions; secondly level is" Meta-cognitive-Level Question" that is further questions than "Cognitive-Level Question"; finally is "Epistemic-Level Question" that student already preparing base cognition, then those question usually including self-understood and self-solved .As the table2.

TABLE 2
PBL PROBLEM LEVELS

Cognitive-Level Question	
Have we considered _____? What if ____? How to do this? What is going on here?	How reasonable is ____? Can everyone define ____? How does this apply to ____? Why is this important? Who needs to be considered?
Meta-cognitive-Level Question	
What still needs to be done? Where is the strategy? How can we fit this together with ____? What have we accomplished? How can we learn more about this?	Have we considered ____ (process or strategy)? What, if anything, in our goals and strategies need to change? Why is this (process) important? What we want to accomplish?
Epistemic-Level Question	
Do we need to know more? Why? How will you decide when you know enough to solve this problem?	How does that relate to our problem statement? How does your role (perspective) influence your knowing and concerns?

Modified from Illinois Mathematic and Science Academy, The center of IMSA, 1995

3. Knowledge category

According to compilation of Z.M. Xu (1989), we classify factors of Office design considerations, into six category: 1. Ambiance (about sense perception), 2.Enterprise performance (displaying corporate images of enterprise), 3.Human being (human considerations of software), 4.Equipment (equipment and software user centered consideration), 5.Function (functional space), 6.Green (hardware greening). As shown in the following (fig.3).

FIGURE 3
THE ITEMS OF RELATED KNOWLEDGE CATEGORY IN OFFICE DESIGN

After collected data that were offered by students' learning process files, researcher analyzed those data based on "knowledge category" and "problem level", and then referred those data to deference kinds of problem levels. The group's records of Office Design problems are shown in the table 3:

TABLE 3
PROBLEM LIST OF THREE LEARNING GROUPS BY PROBLEM LEVEL AND KNOWLEDGE CATEGORY (FOR INSTANCE)

	Group A	Group B	Group C
Cognitive-Level Question	Setting of Main entrance and the secondary one set. (Human Being)	What is the necessity of entrance management of staff? (Human Being)	Do offices and rest area need excessive room? How to excess? Use color or which form? (Human Being)
	Propose advantages and disadvantages of meeting space. (Function)	Propose new corporate image and new enterprises concept.(Enterprise performance)	What kind of office space can effectively retain staff? (Human Being)
	Display areas and the corner of staff rest. (Function)	Why distinguish the main entrance with the secondary one? (Human Being)	Aim at reflective light of computer screen and desk-top to propose specific solutions. (Equipment)

Moreover, according to the cognitive degrees, we divide them into three levels: 1. Cognitive-Level Question, 2. Meta-cognitive-Level Question, 3. Epistemic-Level Question. Show the frequency of each problem level and each knowledge category as figure4:
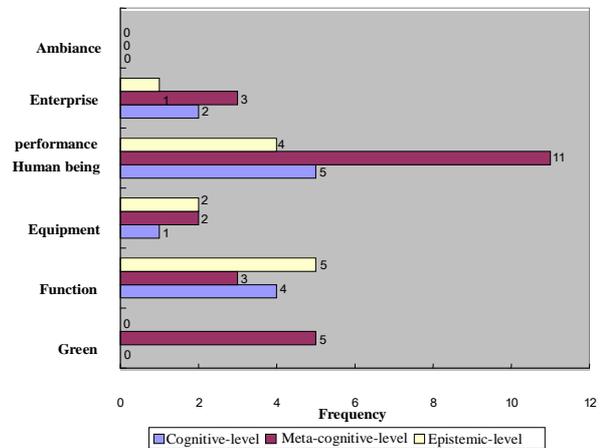
Meta-cognitive-Level Question	Setting of public space landscape. (Green)	Do different features of office spaces need different air-conditioning system? (Equipment)	How to bring natural landscape into office space? (Green) How to make the environment green? (Green)
	Does the best place of eyesight leave for most people to use? (Human Being)	Is the multi-development of unit space the future trend? (Function)	Is it workable to use degrees of illumination to guide route arrangement? (Equipment)
	How color deepen corporate image? .(Enterprise performance)	How to establish effective management system and its relationship with space? (Human Being)	How to create a room where boss and subordinates have positive interaction? (Human Being)
	The relationship of division between public space and personal space. (Function)	Do primary directors need more privacy than staff? (Function)	How to make the arrangements of staff's seating both interactive and functional, and help production efficiency reach the Height? (Human Being) .(Enterprise performance)
Epistemic-Level Question	Concept of class between competent and staff clear or not. (Human Being)	--	Does multiple module space cause chaos? (Function)
	Flexible control of space spaces (ex : The president of American Corporation suddenly comes to visit ...) (Function)	--	Is it worth spending human and material resources when changing spaces? (Function)
	Certain plants absorb sound, carpets and walls have effect of receive sound . (Equipment)	--	About art inspired arrangements, do we need set up centralized display or directly display in the office? (Human Being)

FIGURE 4
FREQUENCY OF PROBLEM LEVELS AND KNOWLEDGE CATEGORY

Based on information from "Scenario" provided by respective design groups, problems are proposed. Knowledge related to office design is compiled into 6 items: 1.Ambiance, 2.Enterprise performance, 3.Human being, 4.Equipment, 5.Function, 6.Green, and problem category frequency tally as follow (Fig.5):
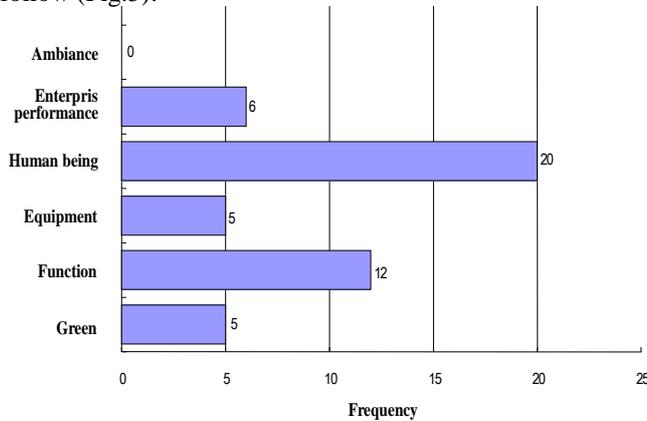

FIGURE 5
FREQUENCY OF ALL KNOWLEDGE CATEGORIES

CONCLUSION AND RECOMMENDATION

1. Problem level aspect

1) Problem level is mostly found in the later cognitive part numbering 24 items. More thinking is involved as compared to other categories. The tutor in the group guides students to engage in in-depth thinking whenever appropriate.

2) In a structure-based knowledge level problem, students further engage in extensive thinking and ponder upon questions not mentioned in the "scenarios" such as Feng Shui (an ancient Chinese tradition of placement and design that guides human beings in living harmoniously with their environments) or problems in other areas such as flexible space or post-repair oriented thinking. There are 12 items in all but the total number of questions remains quite few.

2. Knowledge category aspect

1) The groups did not mention the relationship between cognitive and spatial parts. They are perceived by human organs and fall under cognitive areas. They are rather important in design but are difficult to present in the content of the scenario during PBL teaching. It is recommended that other methods be sought to supplement for the insufficiencies.

2) In the knowledge category, humanity and culture had the most questions showing that students placed emphasis on office space in order to fulfill the basic needs of man. It is followed by functionality which was not a focus since students did not have practical experiences at the time. Thus, the level and aspect of problems discussed are related to personal knowledge, background, and experience.

3) In problem knowledge category, spatial ambiance was rarely discussed. In interior design, some parts fall under sentiment-based aspects and practices. They are not knowledge-based problem discoveries. Topic oriented teaching strategies can be integrated to lead students learn from comprehensive skill and sentiment-based aspects.

4) In PBL interior design courses, learners actively analyzed problems and sought relevant information. Eventually, students in the whole class presented the information they had gathered. They explained the reasons for selecting such information and ideals for their designs. The "Design Criteria" was then setup. It shows that students were able to structuralize and compile distributed questions to setup the criteria.

3. Recommendations on design teaching

By this research process, researchers found "generally design teaching" was "Project-based learning", and this research found "problem-based learning" availed students to go deep into further thinking field, therefore, PBL was valuable for design teaching. Furthermore, when PBL applied to design education, our research suggest that to divided into three parts in PBL teaching process: 1.Problem(Pm) based learning 2.Pm+Pt based learning and 3.Project(Pt) based learning during the design process(as shown in Table1). In the first stage, problem based learning model has more questions and fewer answers. In the second stage, criteria are setup and in the third stage, focus is placed on solution plan seeking instead of problem discovery.

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