

An introduction of problem-based learning models for curriculum change in Chinese universities

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Abstract: This paper presents two PBL models for curriculum changes of Chinese universities. The elective course based PBL model is proposed based on the general and major course categories in the traditional curriculum, whereas the joint-degree PBL model is developed by further including compulsory course categories. For practical implementations, the change of teacher for a student-centered learning context construction is outlined, and a comprehensive comparison for the two PBL model is presented.

1. Introduction

Along with the fast development of engineering education, the problem-based learning has received considerable attentions in recent years [1]. The PBL is shorted for the problem-based learning and the project-based learning, which is an active and student-centered learning method, and students learn by identifying and solving real problems [2], and usually contains four stages to bridge instructor-centered and student-centered learnings [3], i.e. by making the lecture active, informal group activities, structured team activities, and using a problem to drive the learning. Each of them can be named as active learning, collaborative learning, cooperative learning and problem and project-based learning. Besides, there are two ways to organize learning around problems, i.e. the case-based learning (McMaster and Maastricht Models as examples) and the project-based learning (Aalborg Model as example) as shown in Table 1.

Table 1. The McMaster and Aalborg PBL models [4]

McMaster Model	Aalborg model
Problems form the focus and stimulus for learning.	Problem orientation
Problems are the vehicle for development of problem-solving skills.	Interdisciplinary.
New information is acquired through self-directed learning.	Exemplary learning
Student-centered	Participant-directed
Small student groups	Teams or group work
Teachers are facilitators/ guides	

Comparing the two PBL models, the duration of the Aalborg PBL model is about one semester, and type of the activity is project organized. The interdisciplinarity degree of this PBL model is high, and the degree of contextualization is variable. The size of student's group is 4-7 students, and teachers should be expert on the PBL theme. The learning space are available for each PBL group. Besides, projects and problems of the AUU PBL model come from industry, non-profit organizations, teachers and students. They are selected by students, and its definitions are either well or ill defined. Output of the PBL course is a written report that needs oral and group-based exam for individual grades.

Generally, the learning within the PBL model is based on the behaviorism, the cognitivism, and social constructivism learning theories. In the behaviorism leaning, all things that organisms do including acting, thinking and feeling are regarded as behaviors. To change behaviors, the environments is modified or behavioral patterns are changed. In this regard, the behaviorism assumes that a learner is essentially passive, responding to environmental stimuli. Besides, a learner

starts out with a clean slate, and behavior is shaped by positive and negative reinforcement. Therefore, reinforcement, positive or negative, increases the possibility of an event happening again, whereas punishment, both positive and negative, decreases the possibility of an event happening again. The PBL problem can come from a specified request from a client, a conclusion from a scientific study and a call for further research, or an observation of a problem that call for a problem analysis. Additionally, different types of problems require different strategies for the problem analysis. In this regard, the bottom-up analysis from practice to technology based on WHO and WHY questions can deal with a problem initiated by an unsatisfactory situation. The top-down analysis from technology to practice based on WHAT-IF questions might be useful to initiate unutilized potentials. But the theoretical analysis is required to predict technology for some unknown Impacts. The analysis process can be gradually narrowed down from the subject area, the problem area and finally for problem formulation.

In the PBL course design, the Bloom's taxonomy for formulating learning objectives/outcomes which have to be combined with learning methodologies and assessment [5]. At first, we discussed about the John Biggs's constructive alignments among the learning outcome, teaching and learning methods, and the assessment. If we remain the learning outcome as "to become innovative engineers" based on "traditional lecturing system", and the assessment method is based on written individual exams. In the case, the learning outcome is not supported by the teaching and learning methods. Then the question would be what kind of teaching, learning and assessment methods can achieve the learning goal for innovative engineers [6].

The PBL model requires to the teacher can be effectively transformed from course lecture to facilitator in the project stage. Because modern engineering problems are increasingly complex that cannot be defined and solved by knowledge and techniques in a single discipline. This makes the learning process is interdisciplinary in terms of context, methodology, and related knowledge. Many factors such as unclear communication, personal characteristics, uncertainty and doubts, etc. cause barriers for sharing information within a student group. In addition, no one has a global picture regarding the interdisciplinary project, and thus collaborative learning and effective communication are extremely essential in the interdisciplinary course. Therefore, in the interdisciplinary PBL project, teachers are required to be an effective facilitator to increase trust among group members and decrease disorder by encourage dialogue between disagrees, encouraging positive emotional beliefs, and delivering high-quality feedbacks to students learning performance.

2. Reflections on the PBL model

At first, learning is a process through which we adapt to the world around us. It is not the result of something done for us but something we do for ourselves. The most crucial step in learning, therefore, is choosing to make an effort. I always have high expectations for students and insist on hard working. When students are putting their best efforts into class, it is necessary for extra help and time to make it possible and more comfortable to learn. This can either ignite or extinguish students' curiosity and readiness to learn, depending upon attitudes that teachers project in and out of the classroom.

Secondly, teaching and learning are cooperative actions. The learner-oriented teaching promotes learning is both purposeful and enduring. As a teacher, there is the responsibility to know who learners are, what kinds of knowledge and experience they bring to class, and what they want to achieve so that teacher can leave enough rooms to accommodate emerging topics. Teachers who demonstrate curiosity and passion about a subject area motivate students to learn. In this regard, student-centered learning strategies, e.g., the case-based learning, the problem and project-based learning can stimulate intellectual argumentation and cooperation.

Finally, teaching and research can be integrated components. Research contributes to teaching by supplying up-to-date information and experiences to share with students. Reading discipline-specific journals and visiting classes of other instructors continuously produce new ideas. Teaching, in turn, provides contextual questions for researches. Research is, therefore, the means by which I

attain renewal and growth.

Therefore, the teacher's role is or a good teacher should be able to: (1) explain students the importance and benefit of learning some knowledge or skills to motivate their interests and reduce their uncertainty in the beginning, in the meantime it is also better to attract their curiosity to learn more; (2) connect teaching to practice, development and tendencies in real life. Teaching related to research projects or real-life problems is much helpful for motivating students and explaining them the point of learning the subject, which needs experiences to do. At this moment, the performance of lecturing is limited by teachers experience of doing research projects and knowledge of practical issues; (3) use proper teaching method according to different knowledge, e.g. some math related problems, teach students to understand by visualizing, relating problem to practice; (4) teach how to learn based on personal experience, e.g. tips and experiences about math and structural dynamic problems; (5) Share better way of solving problems, and raise questions and discussions to encourage them to think and learn more; (6) inspire thinking about possible future development, and teach students how to communicate with peers for new knowledge. Therefore, to realize the PBL model in Chinese universities, the following two curriculum models are presented.

3. The E2-iPBL Model

The E2-iPBL model is targeted for a student-centered learning process as shown in many other ordinary PBL practices [7]. However, while implementing the model mainly based on traditional curriculum and teaching practices, an issue addressed herein is about teacher's roles, since the faculties normally involved in traditional courses and assessment models for many years might be difficult to be adaptive in the student-centered PBL model. The PBL course model requires teachers to act as different roles across the whole learning processes: (1) the interdisciplinary course designer; (2) thematic topic expert; (3) the provider of modern self-directed learning tools; (4) the creator of student-centered learning context; (5) an effective facilitator and examiner for students' multidimensional competencies.

In general, the interdisciplinary PBL course development starts from "Call for E2-iPBL Courses" organized by the undergraduate academic affairs office. In the course description, the course objective, general learning goals, e.g. cooperation, interdisciplinary, self-direct learning, and among other skills and competences, the implementation and assessment criteria are provided. With personal or group course proposals, a steering committee (study board) will define semester theme based on summited course proposals, and subsequently all submitted courses are grouped into many PBL course groups. Each course group can contain three to five courses that are offered by different disciplines or colleges. Within each PBL course group, all lectures will be given as the traditional ones but with much fewer lecturing hours. In addition, teachers within each such PBL course group need to work coherently in preparing for lecture materials to address the semester theme in an intensive way, and about a half of original course hours are left for the final PBL project. Note that the steering committee will monitor all learning actives within each course group [8]. Feedbacks from the committee, students, and teachers will be further to update and revise course objective, learning goals, implementation details of the E2-iPBL mode in the future.

However, the E2-iPBL interdisciplinary course model also has some deficiencies. At first, the PBL course is realized based on elective courses across many disciplines. Backgrounds of students are quite different in terms of academic year and project experience. It is quite possible to have both of junior and senior students from a discipline. This would be a challenge for the thematic teacher to organize lecturing materials. The problem is also possible for evaluation process, which has to take into account of the factor of academic year for student performance evaluation, because there are divergent learning goals for students in first and sixth semesters. Secondly, the learning goal on disciplinary knowledge cannot comparative with students in the disciplinary. Since we are focusing on the student-centered learning with a particular emphasize of interdisciplinarity, the E2-iPBL project might only require basic knowledge and skill required across many disciplines, yet we are focusing on how to comprehensive and apply them in a systematic manner. However, compared with traditional elective courses offered independently, the E2-iPBL course can go much deeper and

wider by containing much more opportunities focusing on self-directed and constructive learning, critical thinking, and group work. Finally, interdisciplinary training for course participants is normally much less and temporary than those in the ordinary PBL model. The cultivation of critical learning and working competencies required to be reinforced after continuously taking several PBL courses. Especially for those students are primary rested in traditional curriculum environment, it is highly possible to reverse to conventional learning and evaluation styles that focuses on the transfer of independent knowledge and skill. Therefore, a joint degree based interdisciplinary PBL model that further includes some of compulsory major courses in two disciplines is further proposed as follows.

4. The JD-iPBL Model

Rather than simply develop an interdisciplinary PBL course based on the elective course categories in the traditional curriculum, the section is further proposing a joint degree-based interdisciplinary PBL (JD-iPBL) model to further include compulsory major courses in another discipline. To begin with, we consider two engineering disciplines, e.g. mechanical and civil, course elements within the MP and HS categories are almost identical for the two engineering disciplines. In addition, it always has a series of interdisciplinary courses based on the E2-iPBL model. In this regard, the common course within two engineering disciplines have been further extended to FE and SME categories. In other word, the course difference of two engineering disciplines is only limited to compulsory SBK and PT categories. Therefore, with interdisciplinary PBL courses developed based on some compulsory SBK and practical courses, it is possible to develop a joint degree program for a secondary major across the two disciplines.

The E2-iPBL model was implemented based on elective course categories, whereas the JD-iPBL model is designed to further include compulsory major courses. Besides, to be eligible for a double degree, students within the JD-iPBL model are required to satisfy with graduation requirements for the main Major A and a secondarily in Major B. To achieve this, several PBL courses based on various themes can be developed to bridge several courses cross colleges A and B. For instance, a civil engineering student is interested in a secondary degree on computational fluid dynamics (CFD) in mechanical engineering, because analysis and design of modern wind turbines require knowledge and skills across of subjects structural engineering in civil and the CFD in mechanical engineering. It is possible to develop a joint degree program to help the student realize the interdisciplinary learning interest. For implementation, two steering committees from both of civil and mechanical engineering disciplines are work together to determine which courses in CFD are necessary for the secondary degree. Note that courses considered at here includes both of elective and compulsory courses in the FE, SME, SBM and PT categories. Then, several PBL themes that covers structural engineering and CFD topics are systemically set up. Therefore, the JD-iPBL model offers an opportunity for students who are interested in a joint degree by finishing several properly designed PBL courses cross the two disciplines. Compared to the E2-iPBL model, the PBL theme, thematic courses, and the course organization have been clearly defined in the joint-degree training program, rather than temporally organized by steering and teaching committees in the E2-iPBL course model. Note teaching and student learning characteristics in the JD-iPBL model are similar to those in the E2-iPBL model.

5. Conclusion

To realize the interdisciplinarity based on traditional curriculum at Chinese universities, two PBL course models are presented in the section, i.e., the E2-iPBL course model and the JD-iPBL course model. The E2-iPBL model was developed based on elective courses across several colleges within a Chinese university to emphasize the interdisciplinarity. In this regard, multidisciplinary teachers are working together to offer a PBL course for students across many disciplines. The JD-iPBL course model is further considered as a possibility to include compulsory courses as developing interdisciplinary PBL courses, and many such interdisciplinary PBL courses are

systemized together for a joint-degree training program. Compared to the JD-iPBL model, the E2-iPBL model is able to realize the interdisciplinarity and PBL with a minimum change of traditional curriculum. Besides, administrated by the undergraduate academic affairs office, the E2-iPBL course can be treated as a general elective or comprehensive course. Since the course is mainly developed based on elective courses, which have relatively large flexibilities in implementation within the current university administrative system. However, it also has some disadvantages. For instance, the E2-iPBL course might cover many university disciplines. It causes students backgrounds are highly inhomogeneous in terms of the academic year, learning goals and dynamic changes across different semesters. Besides, course teachers are normally from various disciplines and without experiences of working together, which requires high coordination skills. In terms of the Interdisciplinary, the E2-iPBL course can be easily cover many disciplines yet might be difficult to go to very deep. In this regard, the JD-iPBL model will systemically have several PBL courses covers only two disciplines. Students in the PBL model can continuously deal with complex interdisciplinary projects.

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