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The Applications of Problem Based Learning on Computer Control Technology Related Courses

Ming LI[1,a,*], Qiyu YANG[2,b], Lingling YANG[3,c], Yan XING[4,d] and Wei CHEN[5,e]

[1]School of Automation, Guangdong University of Technology, Guangzhou, Guangdong 510006, PRC

[a]mingli4@mail.ustc.edu.cnmail, [b]yangqiyu@gmail.com, [c]lingzi_2003@163.com, [d]yanxing@gdut.edu.cn, [e]chenwei@gdut.edu.cnr

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Abstract. The application of the comprehensive designing using Problem Based Learning (PBL) teaching mode for the computer control technology related courses in School of Automation in Guangdong University of Technology is analyzed to prove that the PBL teaching mode will help improve the students' solving problem creative ability, develop their independent thinking manner and team work spirit, further promote their professional level and competitiveness. Then some suggestions for constructing the mechanism of creative training via PBL are given based on the successful experience of PBL teaching practice.

Introduction

Problem Based Learning (PBL), originally proposed by Barrows, director of the Institute of Problem Learning at the University of Illinois at the University of Illinois [1], is perhaps one of the most innovative pedagogical methods ever implemented in education. PBL was first put into practice as the main teaching method at McMaster University in Canada in the 1960s. Its effectiveness and superiority in facilitating students' acquisition of knowledge and several other desirable attributes, such as communication skills, self-directed learning skills, teamwork, problem solving, sharing information, and respect for others has become increasingly popular across disciplines in higher education[2]. In recent years, with the continuous deepening of the PBL concept, PBL has gradually systemized in its practical process, and gained a worldwide concern in colleges and universities all around the world. At the same time, with the continuous application of PBL in the cultivation of talents in colleges and universities, the related research and practice has also penetrated from the medical field to other fields include education, engineering, industry and commerce, law, economics, management, mathematics, and sociology[3].

In 1993, due to problem-based learning method introduced at the World Medical Education Summit held in Edinburgh, our country began to focus on and study PBL. Since 1990s, PBL began to gradually enter the training mechanism of medical personnel in China. In the 21st century, PBL in China's personnel training has gradually shown its effectiveness and superiority. For example, we have already achieved good practical results using the PBL teaching methods in Peking University, Hong Kong University, China Medical University, Shantou University, Guangzhou University and other colleges and universities in varying degrees [3].

At the same time, with the application of PBL in the college personnel training unceasingly, related research and practice from the medical field including the penetration into the field of education, engineering, business, law, economics, management science, mathematics, sociology etc.[4]

Compared with the traditional teaching mode of traditional inculcation, the biggest difference between PBL teaching method and traditional teaching method lies in teaching idea and teaching subject. PBL was developed as a learning method to implement constructivism.

PBL emphasizes the subjectivity of students in learning. So it hopes to construct a learner-centered form of education. In the process of learning, students play the roles of active problem solvers. They are responsible for finding a solution to the problem designed during the PBL process through active

learning and cultivating self-oriented lifelong learning skills, problem-solving competence, and team work spirit. Teachers on the other hand only play guiding roles which help ensure that all the students have done the appropriate work.

PBL aims to a broader multidisciplinary perspective and encourage students to ponder on ‘‘what to learn and how to learn’’ by issuing ambiguous structured project in real situations. Learners that were involved in such meaningful learning situations were thus able to adapt to problems in real life and effectively improve their theoretical level, professional skills, practical ability and innovation ability [5].

Implementation of PBL Teaching Mode

At present, the curriculum of automation specialty is relatively independent, which means that the courses are lack of the comprehensive and interdisciplinary characteristics. At the same time, the experiments along with the courses generally provide a reference solution for the problem, which can be considered as the validation experiments. The design of such courses is also lack of the cultivation of students’ independent and innovation consciousness.

Therefore, aiming at the above drawbacks of the current course, we have set up comprehensive design practice sessions in computer control related courses in School of automation in Guangdong University of technology. We hope to use PBL teaching mode to improve the students’ application ability and innovation ability to professional knowledge system of our specialty.

A typical PBL tutorial consists of a tutor and a group of students (usually 8~10 students), who facilitates the session. A team needs to be together long enough to allow good team dynamics to develop a final solution. The process can be divided into the following four stages.

Designing PBL Problems

The essence of PBL is that it is a problem oriented teaching method. And the solution of the complex problem is treated as the goal of the learning process. All the learning activities are carried out for solving the problem. So the design of the problem has become the key factor affecting the quality of PBL Teaching. Through the observation and thinking of students' PBL learning activities, the following issues in the design of PBL problems should be paid attention to:

First of all, the design objectives of the problem should be clear, while the problem solving process can reflect the relevant concepts and principles of the course. PBL is successful only if the scenarios are of high quality. In most undergraduate PBL curriculums the faculty identifies learning objectives in advance. The scenario should lead students to a particular area of study to achieve those learning objectives.

Secondly, according to the psychologist Vygotsky's “Zone of proximal development” theory, the difficulty of the designed problem should be moderate, which can build a link between the knowledge the students already have and the knowledge ready to gain from the learning process, so as to maximally stimulate the enthusiasm of students to learn[6].

Moreover, the designed PBL problems should have a certain practical application background, so as to allow students to agree with the value of PBL learning. And since there are no fixed answers and evaluation criteria of the Multidisciplinary cross field problems, the students will become the main body to solve the problem. They will have to find a solution based on their own knowledge structure, so that the students can enjoy a sense of accomplishment while solving the problem and thus improve their self-confidence.

Developing the Implementation Plan

As we have already known that most of the designed problems involved in PBL are multidisciplinary problems, considering the individual differences in knowledge structure, ability and experience for different students, teachers can break down the problem into small modules in order to make PBL experimental teaching mode more feasible and practical.

In this way, the teachers can flexibly control the difficulty of the experiment and guide students to refine difficult, multi-disciplinary complex tasks into more easily implemented, single-disciplinary independent tasks [7].

For example, we can reasonably divide a comprehensive computer control system design task into several independent basic modules and a candidate can be: input channel module, controller module, control object module, hardware design module, software design module, etc., and then the final task of system design is to combine several different levels of the module together.

Seeking the Solution

Due to the relative complexity of the PBL problem, we generally adopt the way of team work, which is one of the important features of PBL. After the team members and tasks are divided, the team members will study and design their respective sub problems respectively. In this way, students will continue to discover the gaps between their own knowledge and the knowledge required to solve the problem [8]. In order to fill these gaps to solve their own problems encountered, students can take different actions, such as attending lectures, going to libraries, looking for consultants and other possible ways to learn the relevant knowledge and skills actively. In this process, all students consciously participate in the solution to the problem and then the whole group and then through the integration of sub-problem solutions to get the final solution [9].

The panel then discussed the effectiveness of the integration program to determine whether the problem has solved or not. If the problem is solved, the working group can enter the evaluation process, if not yet solved, then the students should sum up the new issues after further research, and ultimately form a solution. In fact, it embodies the teaching idea of "constructivism". Each student contributes his own ideas to solve the problem, rather than using the instilling knowledge.

During this learning process, the teachers should closely observe the performance of students, provide the concepts, principles and skills necessary to support for the students to solve the problem, and take proper incentive mechanism to promote a better and faster solution to the problem if needed.

This process can be described by the PBL implementation model of Schmidt, which is concerned with the generative process of learning, as shown in Fig. 1[2]:

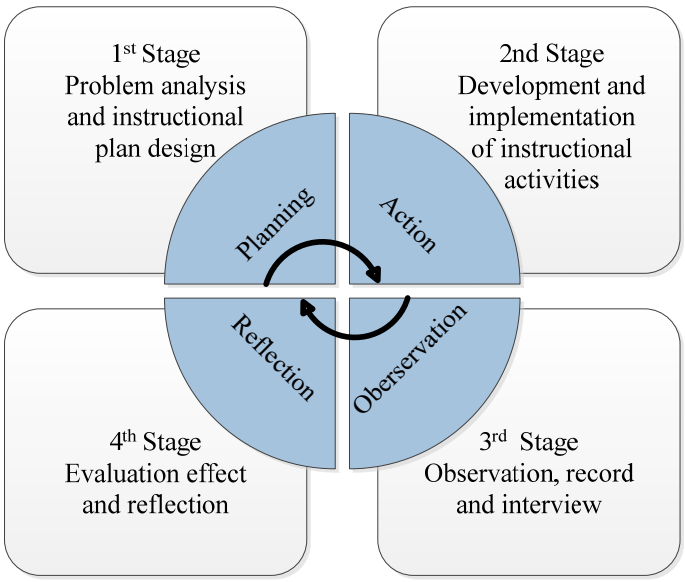

Figure 1. Conceptual framework of PBL implementation model.

As seen from the model, the most important part of PBL is the students' Autonomous learning. The students continuously find new problems on solving the original problem, thus find new knowledge and new methods, and constantly reconstruct their knowledge structure. Then under the guidance of their teachers, to determine their own learning scheme and implement, and ultimately achieve the goal of solving problems.

Assessing the Performance

Student learning is affected greatly by the assessment methods used. The establishment of a reasonable evaluation system is not only an objective means of examining the effect of students' learning, but also an incentive to mobilize students to participate in autonomous learning. If assessment methods rely solely on factual recall then PBL is unlikely to succeed in the curriculum. Therefore, it is necessary to formulate the evaluation system which is compatible with PBL teaching, and form an effective mechanism to encourage students to self-study[5].

All assessment schedules should follow the basic principles of testing the student in relation to the curriculum outcomes and should use an appropriate range of assessment methods. In general, a reasonable evaluation system should be considered not only the results but also the process from the following aspects:

1. The Assessment of students' activities in their PBL groups such as the creativity, the knowledge and skills and individual contribution in solving the problem;
2. The assessment of the group as a whole. The group should be encouraged to reflect on its PBL performance including their preparation before the problem solving, adherence to the process, practical ability, communication skills and team work spirit,
3. It is also helpful to consider the students' summary and reflection after the problem is solved.

Case Study

The course "Comprehensive Design of Automatic System" in our school belongs to the cultivation practice of undergraduates at the innovation level. Its purpose is to further improve the students' comprehensive application ability, promote the students' team spirit of scientific research and engineering development, and cultivate students' innovation consciousness. The following describes the specific PBL teaching model used in the course.

Case Overview

We required students to complete the system design, commissioning and testing of a 2.2KW AC-DC-AC three-phase cage motor speed control system.

At the end of the experimental class, students should submit a speed control system that can actually run with its circuit design schematic diagram and the printed circuit board, including the name of the main circuit components, parameters, manufacturers and explain why to choose these elements. At the same time on the design of the system power commissioning, the team should demonstrate the effectiveness and feasibility of the design system according to the analysis of the observed experimental data results. And we require students provide the speed control system design report to be accompanied by the system software flow chart, the system circuit schematic diagram, the system circuit PCB, source code, etc. in the final submission.

As this is a complex and interdisciplinary integrated experimental problem, covering the analog electronic circuits, digital logic circuits, power electronics technology, Electrical Motor and Drive, automatic control theory, modern control theory, computer programming technology and other related technologies, so it is very suitable for the implementation and promotion of PBL teaching mode.

During the implementation of the whole PBL teaching, students have experienced many aspects such as system structure design, control strategy research, strong power design, weak power design, software design and its realization, system debugging, system performance test, design report defense and so on. So the students have developed their innovative thinking manner and the ability to solve practical problems independently along with the ability for the system integration, assembly and debugging.

Implementation Strategy

In the implementation of this comprehensive experimental course, we divided the students into several 6-8 people teams. In order to make the students more clear about their design tasks, we have

refined the target of the experiment into four sub-targets, namely “system module”, “strong power module”, "weak power module” and "software module", as shown in Fig. 2.

The process of goal refinement is designed to allow students to translate complex issues into relatively simple questions from top to bottom, to search for relevant information, to find solutions to these relatively simple questions, and to integrate the resulting solutions to a complete one.

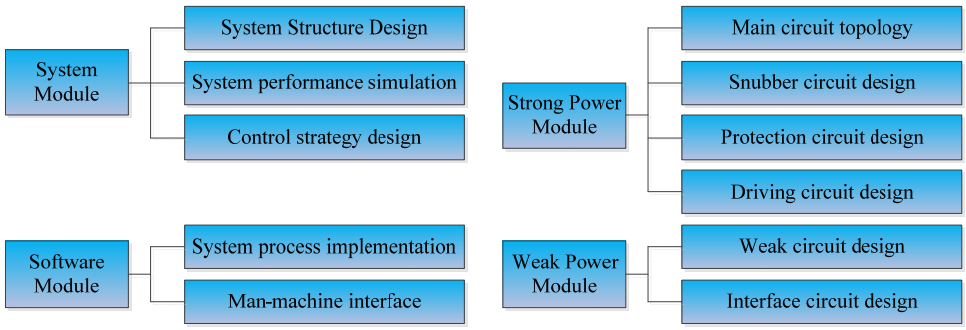

Figure 2. The refinement of the target.

For example, in the design of the “system module” in the first-level sub-task of the problem, we refine the primary sub-task task into three secondary sub-tasks for “system structure design”, “system performance simulation” and “control strategy”, Design of the sub-task “system structure design”, students need to have their own existing knowledge and information in the literature to find the following key issues:

1. Selection of Multi - quadrant operation mode
2. Determination of the system control strategy
3. Selection of the closed loop type
4. Selection and design of the system regulator
5. Selection of the system protection type
6. Requirements of the induction motor parameter
7. Overall structure of the Block diagram of physical structure and control system

For the other sub-goals, in the same way and procedures, students can gradually make clear what they need to do. And then through various types of research and group inquiry, they will find the right way to solve the corresponding sub-problems, and ultimately form a complete solution.

Evaluation System

In the end, when we evaluate the performance the groups and the students, we use the combination of group assessment, group self-evaluation and teacher evaluation. The main concern is the students’ students' innovative, collaborative and autonomous learning ability in the process of solving the problem, focusing on the following aspects:

1. The Students’ usual performance in the participation of the problem solving;
2. Speed system design report: The students should give the detailed explanation and the validation of the specific circuit program design and the control system design is a must;
3. Design report defense results: It mainly examines students’ statements about the solution and answers to questions.

Summary

Through the practice of the PBL teaching mode, we found that this method truly embodies the “student-oriented” teaching philosophy. From the evaluation of students’ solutions, we are also pleased to find a way for the students to build a strong sense of innovation and team work cooperation [12].

Although we have achieved some results in PBL teaching mode, the study of PBL teaching in China is at its initial stage. Since we have great limitations in teaching scope and teaching methods,

the reform of PBL teaching mode still has a long way to go. We hope that our attempts can provide some useful reference for everyone. And more importanly, we wish to draw the peers' attention to criticize, to explore, and to construct a more solid fundation of the PBL teaching mode in China.

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