Applying PBL to the teaching of a computer network technology course

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ABSTRACT: Besides imparting knowledge, the other important task dealt with through education is to guide students toward analysing and solving problems by applying the knowledge learned. With computer networks as a compulsory course for students who major in computing, teachers and students must co-operate to cultivate students' abilities. This cooperation can be substantially improved through reform of the teaching/learning methods, such as the inclusion of problem-based learning (PBL) in professional courses. The aim of this study was to provide guidance to higher professional educationists through application of the problem-based learning mode to the *Computer Networks* course.

INTRODUCTION

Problem-based learning (PBL) is a teaching mode based on learning by solving problems; hence, the phrase, problem-based learning. Further, such learning may involve a project, in which case it can be referred to as project-based learning. The author has applied the technique of problem-based learning to teaching the course, *Computer Networks*, at Henan Normal University, in China [1].

This problem-oriented model makes problem-solving the driving force. The process is facilitated by group discussion and communication combined with teachers' guidance and comments. This is designed to stimulate students' interest in learning, as well as promoting the development of the students. In PBL, real problems are used and autonomous learning and co-operative learning are stressed.

As cognitive coaches instead of lecturers, teachers provide students with guidance that respects the central role of the student. This teaching model stimulates students' learning, initiative and creativity. Students learn to use their knowledge to solve problems and reach teaching goals. The model characteristics are shown in Figure 1.

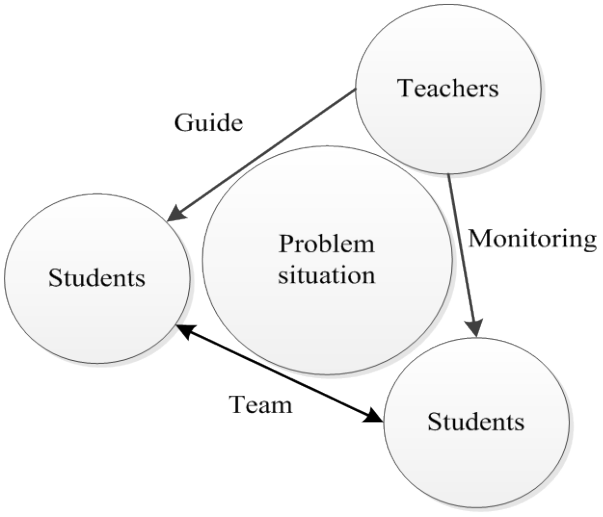

Figure 1: PBL teaching mode.

How PBL Compares with Traditional Teaching

In comparing PBL with traditional teaching, there are teaching goals, methods and achievements to consider, as shown below:

- *Teaching goal:* PBL encourages the development of high-level thinking skills and autonomous learning.
- *Teaching methods:* PBL puts students at the centre of learning. It stresses the equality between students and teachers, as well as the active knowledge-acquisition and self-development of students.
- *Teaching achievements:* PBL develops students' proficiency in exploration and research through using their ability to solve problems.

The comparison of PBL with traditional teaching is shown in Table 1.

Table 1: Comparison of PBL with traditional teaching.

Considerations	Traditional teaching method	PBL teaching method
Teaching objectives	Each course has been set up with a depth, breadth and comprehensive teaching system.	Practical knowledge of learning and development of high-level thinking to cultivate the ability of students.
Teaching methods	With teachers and teaching at the centre, students are always passive.	The student is at the centre, focusing on the problem. Teachers guide but the emphasis is on students' initiative.
Teaching results	The student is in a state of being taught and tends to *learn by rote*.	The student is good at exploring and solving problems, and has an appropriate application knowledge.

APPLICATION OF PBL TEACHING

Implementation of the PBL model in the teaching of Computer Networks involved the following: problem presentation, division into groups, group autonomous learning, group discussion and collaborative learning; group communication, summary and evaluation [2]. Problem-based learning is based on complex problems that should be as close as possible to actual issues and the real world.

The Problem in PBL

The PBL model emphasises that, with the guidance of teachers, students should use their experience and knowledge to identify the skills needed in problem-solving. Also, they need to use learning materials to assimilate new knowledge and to establish the connection between the old and new knowledge, so as to reach effective problem-solving. Teachers must present a problem with just enough information to give students a clear understanding of it. The problem should be linked to real life, which stimulates students' interest and enthusiasm. The teacher has multiple roles, viz. problem-setting, guiding and fostering the students, reviewing and evaluating, and recording and monitoring. This is in contradistinction to the traditional role of the teacher as the transmitter of knowledge. Five characteristics of the problem are shown in Figure 2.

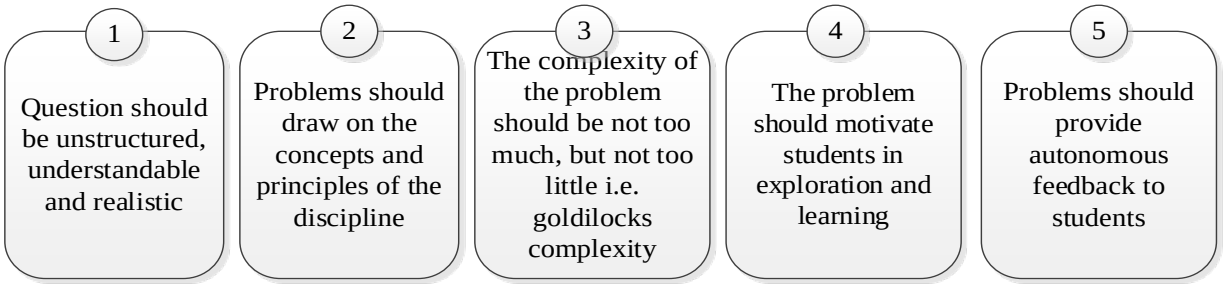

Figure 2: Five characteristics of the problem.

Group Learning Based on Co-operation and Exchange of Information

The second step in PBL is to divide learners into several learning groups. This arises from the necessity of co-operation between learners, which is influenced by the complexity and authenticity of the problem. The differences of personality

and abilities of students in a group provide different perspectives when analysing and solving problems. First of all, teachers should make clear the responsibilities and tasks for each group. In addition, tasks and responsibilities of each group member need to be defined clearly, in order to ensure that all students study and develop independently, while actively involved in problem-solving.

Depending on the complexity of the problem, each group can share information with other groups after they have independently fulfilled their tasks [3]. Next, teachers should offer timely help, guidance and encouragement to students. Finally, teachers need to put forward suggestions for improvement on the basis of reviews and summaries. This ensures that students properly understand the problem and have gained knowledge in solving it. Figure 3 shows the general flow of steps in implementing PBL.

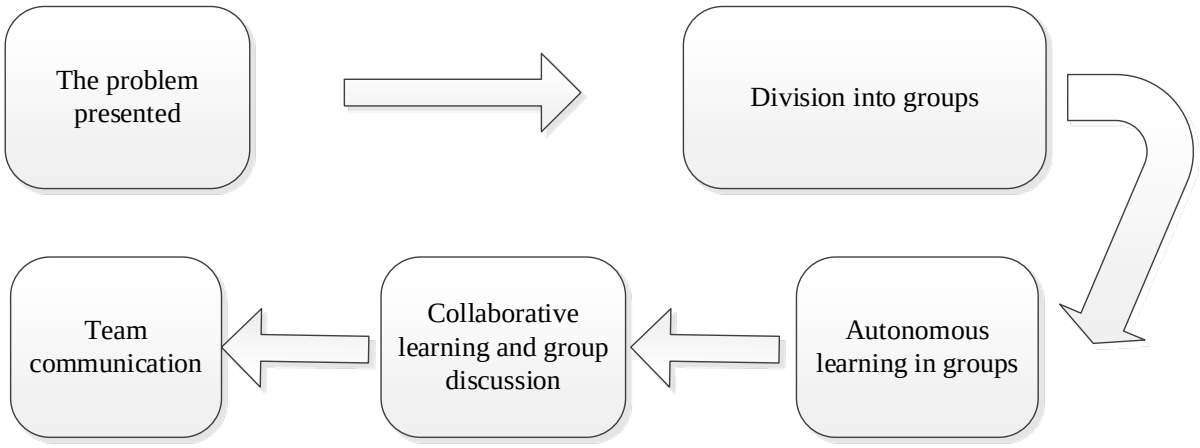

Figure 3: Implementation of PBL.

Summary and Evaluation in PBL

Students are required to evaluate their role and learning within the group under the guidance of the teacher. Then, groups evaluate each other, as well as sharing their learning experiences and outcomes. Last, teachers are required to summarise and identify deficiencies. Hence, there is a multi-level and diversified evaluation system [4].

There are two reasons for teaching evaluation. The first is to stimulate students in knowledge exploration and the second is to improve teachers' teaching ability. The PBL teaching assessment combines formative and summative assessment with students' self- and mutual-evaluation, as well as written reports and oral presentations.

EFFECT OF PBL ON LEARNING

An experiment was carried out to determine the effect of PBL on learning computer networks in a higher education institution. Experimental and control groups were selected among students in the Computer Networks course. The experimental group was taught using the PBL method, while the control group was taught using traditional teaching methods.

Statistical Techniques

A Z-test of significance is appropriate when sample sizes are large, normally taken to mean greater than 30. The size of the experimental group was $N_1 = 44$; the size of the control group was $N_2 = 43$. The formula for the Z value is:

$$Z = \frac{X_1 - X_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

where X_1 and X_2 are the means of examination results and S_1 and S_2 are the standard deviations of the results for the two groups. The significance probability level was set at $p = 0.05$. If $p > 0.05$, then, scores on the final examination are not statistically different.

Results of the Experiment

Comparison of performances on the Computer Networks course between the experiment group and the control group in different periods is shown in Table 2, where the N_i, S_i, X_i are the number in the group, standard deviation and group mean, respectively.

Table 2: Comparison of experimental and control group performances.

Group	December 2012					April 2013					June 2013				
	N_i	S_i	X_i	Pass (%)	Good (%)	N_i	S_i	X_i	Pass (%)	Good (%)	N_i	S_i	X_i	Pass (%)	Good (%)
Experimental group	44	13.8	68.8	71.8	22.9	44	13.9	74.5	81.9	31.1	44	14.8	78.3	96.9	39.1
Control group	43	10.5	63.1	61.5	16.9	43	12.1	66.5	69.9	18.9	43	12.2	68.8	73.2	19.8
Z	2.132					2.902					3.328				
F	$p < 0.05$					$p < 0.01$					$p < 0.01$				

The results show that the experimental group performed better at a significance level of 0.05 in December 2012, and better at a significance level of 0.01 in April and June 2013. The experimental results confirm the hypothesis that PBL improves training results [5].

Problem-solving Ability Using PBL

Results for the problem-solving ability of the experimental and control groups is shown in Table 3.

Table 3: Problem-solving ability of the experimental and control groups.

Solve a problem	Group	Yes (%)	Did not express an opinion (%)	No (%)
Through literature, networking for help	Experimental group	72.4	23.9	3.5
	Control group	41.8	28.6	28.4
Get help from other learners	Experimental group	79.6	12.6	7.3
	Control group	44.7	41.6	12.9

Table 3 shows that the application of the PBL model in computer teaching improves students' information literacy and develops their ability to solve practical problems through independent learning.

ADVANTAGES OF PBL TEACHING IN THE NETWORK TECHNOLOGY COURSE

PBL Model Leads to the Realisation of the Teaching Goals

The general goal of information technology courses, including Computer Networks is to develop students' information literacy and the ability to solve real-life problems encountered in computer networks. Students can collect, process and express information according to a task's requirements and so improve their ability to analyse and solve problems.

Problem-based learning presents students with real problems that students solve in co-operative groups by collecting relevant information and through discussion. Therefore, the goal of information technology courses and PBL are consistent. The combination of the two promotes problem-solving and the ability to use relevant software [6].

PBL Improves a Student's Interest in Learning

The application of PBL improves students' interest in learning. Students' study in groups and the communication and reporting takes them out of a traditional classroom setting. This provides students with opportunities to project themselves forward in group activities. Students can express themselves freely, which is enjoyable. Accordingly, their interest in learning is significantly enhanced.

PBL Cultivates Students' Ability to Solve Practical Problems

The network technology course is practical and operationally oriented. The teaching model combines communicating with practising. An overemphasis on teachers' teaching leads to students' lack of creativity and imagination, as well as

their lack of initiative in deeply exploring issues. By comparison, the aim of PBL is to deal with, and solve, problems. Solving problems is an active way of stimulating learning and generating enthusiasm. The priority given to practical problems cultivates students' practical problem-solving ability.

PBL Promotes Autonomous Learning

The PBL problem-centred approach requires students to find information from all relevant resources so as to solve problems. They need to plan their learning and construct new knowledge on the basis of the old. So, they become independent learners and thinkers.

PBL Cultivates Co-operation

In PBL, co-operation and discussion between teams are indispensable, because group discussion is the main mode of learning. Group discussions enable students to find the best solutions to problems. Team co-operation involves students' mutual help, exchange of knowledge and also the communication of feelings.

Since PBL problems are real and complex, it is difficult for one individual to complete work by themselves. Thus, students need to work in a group, analysing problems and collecting information so as to solve a problem. Through group co-operative learning, students become willing to collaborate with others and also become good team-workers.

CONCLUSIONS

In conclusion, it was found that implementing PBL teaching will improve students' learning ability, as well as their attitude to learning and their study habits. Problem-based learning improves a student's ability to solve problems. In addition, group co-operative learning that is a feature of PBL helps students to improve their communication skills, their ability to co-operate, and their ability to collect and process information.

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