Research on Teaching Methods of Postgraduate Courses Based on PBL

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***Abstract*—As a teaching model based on learning transfer theory and constructivist education ideology, the problem driven teaching model is an effective method to combine knowledge inheritance and knowledge reconstruction to cultivate innovative talents. Under the traditional teaching model, schools often only focus on achievements and achievements in the cultivation of graduate students, while ignoring the cultivation of their own innovative and practical abilities in the scientific research process. After realizing the drawbacks of this traditional teaching model, this article applies the problem-driven teaching model to the course "Signal Detection and Estimation Theory", and hopes to strengthen the problem awareness and practical ability of graduate students in scientific research and learning throughout the entire process of cultivating graduate students, so as to cultivate their ability to discover, analyze, and solve problems, This is the key to cultivating students' innovative research and professional practical abilities. Under this teaching method, object-oriented autonomous learning has been achieved, further stimulating the innovative consciousness and spirit of graduate students.**

***Keywords*—problem-based, signal detection and estimation theory, innovation awareness, autodidacticism**

I. Introduction

Postgraduate curriculum teaching is an important part of postgraduate training. The construction of an innovation-oriented country has put forward new requirements for innovative education of postgraduates. As an important carrier of postgraduate innovative education, how to guide and cultivate postgraduate innovative consciousness, innovative thinking, and practical ability in postgraduate courses, how to make postgraduate course teaching better serve innovative education, how to promote innovation based on courses and practice, and how to give full play to the role of postgraduate course teaching in postgraduate innovative education are important topics worth discussing in the field of postgraduate education [1, 2].

Problem-Based Learning (PBL) is a teaching mode based on the theory of learning transfer and the educational thought of constructivism. It is a teaching method that combines knowledge inheritance and knowledge reconstruction to cultivate innovative talents.

A. Problems in Traditional Course Teaching Methods

As a basic link to achieve the goal of postgraduate training, postgraduate curriculum teaching plays an important role in the process of cultivating postgraduate research ability and innovation ability.

However, most local multidisciplinary universities, which mainly focus on undergraduate teaching, often adopt the undergraduate teaching mode in postgraduate curriculum teaching, and carry out classroom teaching step by step according to the content of reference textbooks. Practice shows that this teaching method restricts the cultivation of graduate students' innovative thinking and innovative ability. Moreover, under the traditional teaching mode, the management department of graduate students and the cultivation of graduate students only pay attention to the curriculum achievements, published journal papers, completed dissertations and other aspects, and ignore the cultivation of graduate students' awareness of problems, practical ability, scientific research level, and innovation ability in the whole process of postgraduate cultivation. The postgraduate students thus cultivated lack the subjective initiative and quality of scientific research innovation, which violates the order of postgraduate education and training.

B. Innovation Ability is the Fundamental Requirement of Postgraduate Training

Postgraduate education is a high-level professional education characterized by research. High level professional education with research as its main feature is the fundamental requirement of postgraduate education. Postgraduates are not only receivers of knowledge, but also creators of knowledge. Postgraduate education should focus on cultivating students' ability to analyze and solve problems. The core of research is innovation, which is realized in the process of finding and solving problems. "Problem awareness and problem-based" is the basis of innovation ability. To cultivate graduate students with innovative research ability, we need to implement the problem driven teaching method.

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C. The Soul of Problem Driven Teaching Method Is to Stimulate Exploration and Promote Innovation

PBL is a teaching mode based on the theory of learning transfer and constructivist educational ideas. In constructivism, knowledge is not imparted to students through instillation by teachers, but is acquired by students in certain contexts, with the help of teachers and in interactive communication. Under the theory of learning transfer, learning in one situation will affect students' learning in another situation. Creating situations, stimulating emotions, communicating and collaborating, and constructing meaning are the main aspects of PBL. Revealing contradictions through questions, provoking doubts, stimulating exploration, and promoting innovation are the soul and vitality of the PBL.

The PBL uses problems as the starting point for learning, allowing students to actively construct knowledge around problems and independently seek ways to solve them. Combining PBL with systematic knowledge and skill learning to cultivate highly qualified professionals with innovative thinking and research ability is an urgent problem to be solved.

II. The Research State on Problem-Driven Models in Postgraduate Courses

In recent years, much work has been done in China on problem-based graduate course teaching reform. Liu *et al.* [3] explored the PBL, proposed the necessity of PBL from the current situation of probability statistics, and discussed the problem-based probability statistics teaching method and teaching design with practical examples; Zheng [4] explored the problem-based teaching reform of graduate courses, introduced the problem-based idea into the course teaching for the graduate numerical analysis course, and gradually formed the "problem-based" teaching method. In [4], he introduced the problem-based idea into the postgraduate numerical analysis course, and gradually formed the teaching mode of "problem-based", the lecture system of "theory lecture-topic discussion-extra-curricular assignment", and the teaching system of "in-class closed-book examinations and extra-curricular assignments". Zhao *et al.* [5] discussed the curriculum reform based on the cultivation of innovation ability of postgraduate students, and infiltrated the traditional teaching mode of molecular biology courses with problem-driven learning methods and inspiring teaching methods such as special lectures; Wang [6] proposed a research ability-oriented approach to postgraduate education. In the context of the current reform of postgraduate training mechanism, which focuses on improving the research and innovation ability of postgraduates, and in the face of the objective reality that postgraduates, especially master's degree students, have limited opportunities to participate in research projects, Wang [6] proposed to strengthen the research ability of postgraduates by relying on the course selection system, curriculum, teaching methods, and teaching atmosphere involved in the curriculum system. It is a rational choice for the curriculum reform of postgraduate education in China at this stage to enhance the cultivation of postgraduate research ability and realize the return of the essence of "academic inquiry" in postgraduate education. Fan *et al.* [7] implemented the application and practice of computational thinking teaching with the PBL, and proposed to combine the thinking method of computational thinking with the PBL to build a PBL incorporating the concept of computational thinking. It can be seen that in the teaching reform of graduate courses, different scholars have explored and implemented various teaching reform approaches according to the characteristics of different postgraduate courses and achieved good teaching performance.

III. The Implementation Process of Problem-Based Learning in the Course of "Signal Detection and Estimation Theory"

The theory of signal detection and estimation has been widely used in various fields, such as communication, radar, satellite navigation, automatic control, pattern recognition, etc. In the classroom, connecting knowledge points with engineering practice in different application fields not only deepens students' understanding of knowledge, but also improves their interest in learning. By introducing PBL teaching method into the graduate class, students' ability to understand and master knowledge has been enhanced, and the teaching effect of the course has been comprehensively improved.

A. Principles of Problem Design

The design of the questions should be both basic and research-oriented, including the hot issues in related fields, cutting-edge issues, etc. There are four types of teaching questions

1) Fundamental problems

In the course of "Signal Detection and Estimation Theory", it mainly includes basic concepts and basic criteria, such as maximum likelihood criterion, minimum error probability criterion, etc.

2) Process problems

It refers to how to use basic criteria to set channel parameters.

3) Applied problems

It refers to the use of detection and estimation criteria to complete the detection of radar targets.

4) Expanding problems

It refers to how to use Kalman filter and Wiener filter to detect and estimate signal waveform.

Problem design should follow the following four principles:

(1) Realistic and target-oriented

(2) Appropriate difficulty to stimulate interest

Setting the problems too easy is not conducive to increasing students' interest in learning, and the level of difficulty should start from the actual level of most students.

(3) From simplest to more complex and step-by-step

In the course of "Signal Detection and Estimation Theory", students are required to design progressive problem chains or technical routes, to help inspire and promote stimulate inspiration and exploration.

(4) Mobilize the initiative and enhance the participation

In the discussion session of the course, for the filter parameter variation, each student is required to actively participate in the discussion and be able to give conclusions based on the trend of the simulation data.

B. Implementation Process

The implementation of the PBL should focus on the problems, grasp the key points, and adopt the "five links" teaching method based on the problem-driven, which specifically includes the following five links:

1) The first link: create context and ask questions

The specific implementation steps are as follows:

a) Create a situation: Create questions relevant to the learning objectives of the next class and motivate students, distribute relevant references to students, and ask them to read the literature and write literature reading reports with their problems. In the process of literature reading, students have initially formed an understanding of these questions and come into class with doubts to avoid numbness in learning.

b) Solve the problem: We arrange students to collect and summarize the questions and doubts of each student in the process of literature reading, and give feedback to the teacher in time, so as to use it as a reference for teaching design, including how to organize teaching, how to design teaching focus and how to guide students to participate in discussion, etc.

Table I lists the curriculum objectives of the course "Signal Detection and Estimation Theory", the PBL problems created according to the actual engineering background and the corresponding relationship between relevant knowledge points [8, 9].

TABLE I. PBL PROBLEMS CREATED ACCORDING TO ACTUAL ENGINEERING BACKGROUND

Course Objectives	Created PBL Problems	Knowledge Points Covered
Course Objective 1: Master the basic theory of signal detection and the detection methods and criteria of various signals in the background of Gaussian noise.	Radar detection is a statistical detection based on noise and clutter background. Why does the radar system adopt the Naiman-Pearson CFAR detection criterion?	CFAR detection criteria
	Analyze why the best reception in the communication system is based on the minimum error probability?	1. Optimum receiver 2. Minimum error probability
	Analyze why the error probability of the binary communication system is related to the signal-to-noise ratio. The larger the signal-to-noise ratio, the smaller the error probability?	Binary communication system
Course Objective 2: Master the basic theory of signal estimation and the estimation methods and criteria of various signals in the background of Gaussian noise.	Taking the optimal reception of BPSK modulation signal of binary phase shift keying as an example, the reason for its low bit error rate is analyzed?	Binary phase shift keying
	How to understand the problem of receiving signals with minimum error probability in digital communication?	Minimum error probability reception
Course Objective 3: Correctly understand the application of detection and estimation technology in communication, radar, sonar and other information transmission and processing.	Why use Kalman filtering algorithm to speculate the target track?	Kalman filtering
	What is the role of least squares in navigation and positioning algorithms?	Least squares estimation

2) The second link: Independent learning and problem expansion

On the basis of raising questions, provide students with foreign literature, as well as some historical data, etc., and propose planning plans and verification ideas. Students are required to carry out independent learning. Besides the content designated by teachers, students also need to use the library, the Internet, and other channels to access relevant references and books.

3) The third link: Classroom discussion and interactive communication

Organize students to communicate with each other in groups (If 30 people are counted, it is better to divide them into 6–7 groups), and let students give a plan through discussion.

4) The fourth link: Classroom lectures, summarize and improve

Based on the above discussion, we will summarize and sort out the plans proposed by each group of students. Teachers will give targeted explanations and answers to the problems that are easy to occur in the plans formulated by students.

The teacher makes comments one by one according to the reports of each group. The comments can include whether the assumptions put forward are scientific, whether the students' thinking about the problems is clear, whether the cooperation between team members is smooth, whether the data collected is perfect, whether the methods of solving the problems are reasonable, and whether the conclusions drawn are correct.

5) The fifth link: Throwing away a brick in order to get a gem, inspiring and inducing

In the course summary, point out the ideas that can be further improved ideas and thoughts to stimulate students to think further.

C. Teacher-Student Cooperation in the Implementation of Problem-Based Learning

1) Give full play to the tutor's guidance

After graduate students enter the project and start their research, the tutor should play a leading role and do a good job in the following three aspects, as shown in Fig. 1.

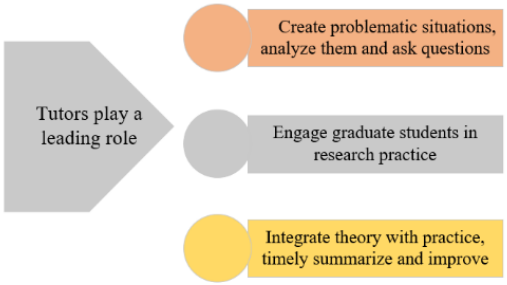

Figure 1. The leading role of the tutor.

Firstly, create a problem situation, analyze the problem situation and ask questions. The tutor should explain to postgraduates the goals and objectives of the research project, as well as the problems, difficulties and methods to be solved.

Secondly, let postgraduates put into scientific research practice. In scientific research practice, tutors should boldly let go and give postgraduates a dominant position in raising and solving problems. We should guide graduate students to combine scientific research practice with their professional knowledge and scientific and technological development. We should guide graduate students to carry out scientific research with problems, and consciously digest, apply and test the knowledge learned in the classroom and books in scientific research practice.

Finally, pay attention to integrating theory with practice, and timely summarize and improve. Guide graduate students to closely follow the development of science and technology, closely link with reality, combine their professional knowledge with new problems and discoveries encountered in scientific research practice, think more and ask more questions, communicate with tutors, other students and experts, and write a summary of scientific research practice on this basis.

2) Give full play to the tutor's guidance

Tutors can design research topics for students and ask guiding questions to develop students' ability of self-discovery, self-analysis, and self-evaluation by inspiring them to think; for specific problems, tutors give positive or negative evaluations and inspire students to analyze the reasons for them and offer correct explanations. Tutors can also give students relative freedom to review literature, find topics of interest, and propose solutions on their own; Tutors give correct opinions or suggestions for the research ideas and solutions proposed by the students on the topic.

IV. Conclusion

To implement the PBL in the course of "Signal Detection and Estimation Theory", the teaching process of the whole course starts with the raising of problems, focuses on the analysis and research of problems, focuses on improving students' ability to analyze and solve problems, and aims at solving problems. In addition, allowing students to participate in the tutor's professional research practice is the application, inspection and improvement of the course content, the extension and deepening of problem driven teaching, and the key to cultivating students' innovative research ability and professional practice ability.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ji Ce and Cao Chunhong conducted the research; Cao Chunhong and Geng Rong analyzed the problems; Ji Ce and Zhang Siyu wrote the paper; all authors had approved the final version.

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