

Exploration of the Multi-Integrated Research Teaching Model from the Perspective of Constructivism

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Abstract: Based on the teaching idea of modern constructivism, this paper puts forward the research teaching model of multiple integration in view of the three problems existing in postgraduate teaching at present. This teaching model uses space-time integration, online and offline integration, curriculum ideological and political integration, problem-driven - project teaching - case analysis of multiple research teaching integration, integrating "theory" and "practice", to achieve the coupling of knowledge and practice. Taking the course of modern design methodology as an example, this paper studies the connotation of teaching model, teaching design and teaching strategy, evaluation method and teaching effect.

Key words: Constructivism; Multiple integration; Research based teaching

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In 2020, the Ministry of Education, the National Development and Reform Commission and the Ministry of Finance in China jointly issued "Opinions on Accelerating the Reform and Development of Postgraduate Education in the New Era", proposing to strengthen the cultivation of postgraduate students' knowledge innovation ability and professional practice innovation ability, and improve the quality of postgraduate courses. However, in the current teaching of postgraduate courses, teachers mostly adopt the traditional teaching mode and teaching strategy, students passively accept knowledge, lack the process of independent knowledge construction, which is not conducive to the cultivation of postgraduate academic ability, innovation ability and critical thinking.

Compared with undergraduate students, graduate students should pay more attention to knowledge transfer ability, academic ability and problem solving ability. The educational thought of constructivism [1-3] holds that on the basis of learners' original knowledge experience, students should actively construct knowledge system through their active exploration. Research-based teaching takes student learning as the center, adopts teaching forms such as case analysis and problem-driven, increases classroom interaction [4], and guides students to study independently, explore actively and reconstruct knowledge. It can be seen that the two teaching concepts are consistent.

The combination of constructivism educational thought and research-based teaching mode, and the research of multiple integration of research-based teaching mode to maximize the ability of students, will be conducive to improving the quality of graduate training. Taking the course of modern design methodology as an example, this paper expounds the system of teaching model, implementation strategy, evaluation method and evaluation effect.

1. The problems in the classroom teaching of graduate students

With the increase of enrollment, the rapid progress of subject knowledge and the reform of enterprise talent demand, the traditional teaching model cannot adapt to the current demand, resulting in the contradiction between the demand side and the supply side of talent [5]. Through the investigation and analysis of the learning style and classroom teaching mode of graduate students in the department of mechanical engineering of North China Electric Power University in the past five years, it is found that the main problems in classroom teaching of graduate students are as follows:

(1) There are great differences in the learning basis of graduate students

There are great differences in the cultivation schemes of undergraduate students in major categories of machinery, which brings great challenges to the teaching of postgraduate courses. If the traditional teaching model is adopted for the course teaching with different students, it will lead to the phenomenon that some students cannot understand it and others think it is too simple. Therefore, it is necessary to explore a new teaching model to solve this problem.

(2) Postgraduate students are not enthusiastic about learning

In the postgraduate stage, the research direction of students is more focused, and the postgraduate courses need to learn in addition to the relevant courses of this direction, but also need to learn some courses of this discipline and public basic courses. However, some graduate students think that courses outside the research direction are useless, so they do not need to put too much effort into it, resulting in the phenomenon of low enthusiasm for learning. How to organically integrate students' research direction with the course and enhance students' learning enthusiasm also needs to explore a new teaching model.

(3) The knowledge system of curriculum teaching needs updating

Take the mechanical discipline as an example, additive manufacturing, intelligent manufacturing, generative design, intelligent design and other technologies have developed rapidly, while the publication speed of textbooks is much slower than the progress of technology, but enterprises need graduate students to master these new technologies. This is an important reason for the disconnection between talent training and talent demand. The existing teaching model needs to be updated in order to train talents with technical ability to solve the "bottleneck" for the country.

2. Multiple integration of research teaching model

In view of the problems existing in the classroom teaching of graduate students, this paper puts forward a diversified and integrated research-based teaching model from the perspective of constructivism, focusing on student learning and strengthening students' active inquiry. Research-based teaching model includes research-based teaching and research-based learning [6-7]. From the perspective of teaching, students can become the protagonists of the classroom through reasonable teaching design and implementation of teaching strategies. After many years of teaching practice, the paper puts forward a pluralistic research teaching model which combines problem driven, project teaching with case analysis.

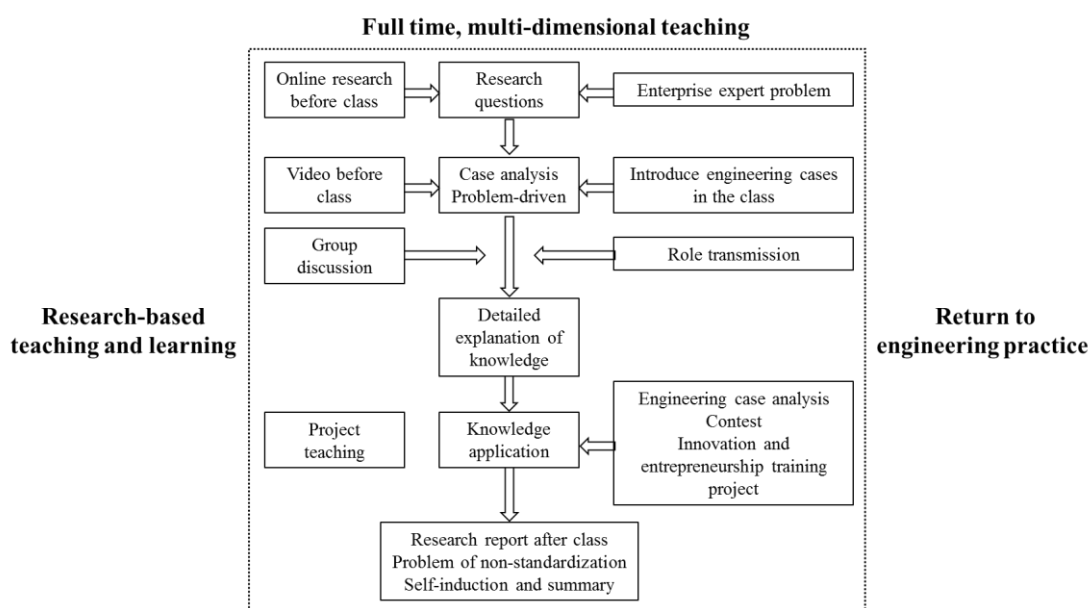


Figure 1 Multiple research teaching model

2.1 The connotation of multiple research teaching model

In order to solve the teaching problems in the case of differences in learning basis, the method of mixed online and offline teaching is adopted to record corresponding online resources for students with different learning basis, supplemented by online discussion and Q&A on basic questions, so as to make up for the differences in students' original knowledge basis. For the mixed teaching, in addition to the recording of resources, the most critical thing is to do a good job in learning situation analysis, grasp the real situation of students, and teach students according to their aptitude.

Problem - driven teaching is an effective teaching model for classroom interaction, and the choice of questions is particularly important. In the course teaching of postgraduate students, theoretical problems with a certain depth and breadth should be selected, or complex engineering problems that require collaboration of interdisciplinary knowledge. According to the characteristics of knowledge points, questions are raised in the form of videos, problems encountered in life and academic papers. Teaching is organized by means of group discussion, teachers' difficulty to promote questions step by step, and role transformation, so as to change passive

acceptance into active exploration.

Project teaching is the embodiment of typical constructivism education thought. Through team coordination, discussion and questioning, the design team can solve the difficult problems encountered, so as to complete the construction of knowledge. Project teaching in postgraduate course teaching should be different from undergraduate teaching. Based on the training requirements and objectives of postgraduate students, project teaching should be more advanced and challenging. Students should be required to solve interdisciplinary scientific research problems through self-study and independent access to literature.

The comprehensive application of various teaching methods can solve the problems existing in the current postgraduate teaching. In the actual classroom teaching design, we should choose flexibly according to the specific knowledge points.

2.2 The integration of multiple research teaching models

Based on students' cognitive rules and learning characteristics under the Internet environment, the paper puts forward the multi-integration teaching mode which realizes the coupling of knowledge and practice. Combined with enterprises' demand for innovative talents' ability to solve complex engineering problems at the forefront of science and technology under the new situation, a new model of six-integration teaching is proposed to solve the disconnection between knowledge and practice.

The specific six integration measures are as follows:

- (1) Make full use of the advantages of the Internet, realize information sharing based on high-quality remote resources, and expand the depth and breadth of "knowledge".
- (2) Integrate online and offline, strengthen students' active exploration and independent learning, and expand students' ability to analyze and solve problems.
- (3) Integrate curriculum teaching with curriculum ideology and politics to cultivate students' scientific literacy, critical thinking and correct values.
- (4) Adopt the integration of multiple teaching modes, take the project as the guide, organize classroom teaching with question exploration, case analysis and group discussion, reconstruct the curriculum knowledge system according to the needs of enterprise talent training under the new situation, and strengthen students' ability.
- (5) Combine academic research topics with research-based teaching to cultivate students' ability to solve scientific problems.
- (6) Through the integration of industry, university and research, so as to return to engineering practice, solve the problem of disconnection between theory and practice, and improve students' comprehensive practical ability.

2.3 The teaching strategy of pluralistic integration of research teaching mode

In the teaching design, the teaching implementation strategy of combining pre-class (autonomous learning + question research + online autonomous learning detection), in-class (problem-driven + project teaching + case analysis and other research-based teaching) and after-class (time-limited practice + case discussion + frontier exploration), is adopted to give full play to students' subjective initiative. Through all-round question inquiry and discussion based on scientific inquiry ideas, students' ability to analyze and solve problems is cultivated.

For postgraduate teaching, pre-class autonomous learning includes MOOCs (to strengthen the weak), research in advance of class discussion, and research on academic problems combined with postgraduate research. All of these contents are completed online, and students submit their learning results online. At the same time, it is necessary to provide an online discussion area for students to answer questions online, so as to grasp the basic information of students before class and do a good job in the analysis of learning situation for the teaching of this class. Make full use of the advantages of online teaching to prepare for the efficient implementation of differentiated teaching.

In class teaching, based on the statistical data of pre-class learning and on the basis of mastering students' learning pain points, the teaching method of guiding students to take the initiative to analyze and explore is adopted. In combination with the frontier of the discipline and the research direction of the students, the academic discussion is conducted under the guidance of the teachers in a problem-driven way, the students are led to think about the problems with the method of scientific inquiry, the practical engineering cases and project topics are guided throughout the whole process, and the knowledge learned is internalized into the ability under the guidance of the constructivism education thought.

After class, challenges faced by the enterprise and frontier issues of the discipline will be taken as after-class thinking questions, and learning results will be submitted in the way of writing research reports to cultivate students' ability to write scientific and technological literature and research academic issues.

3. The application of multiple integrated research teaching Mode in "Modern Design Methodology"

3.1 Basic introduction to the course of modern design methodology

The course of Modern Design Methodology is a compulsory course for academic and professional master students of mechanical engineering in North China Electric Power University. The course is 32 credit hours and 2 credits. This course aims to develop students' ability to use modern design methods to solve practical engineering problems, as well as modern design ability, innovation ability and academic ability of mechanical systems. The course mainly teaches mechanical system design methods - functional analysis, mechanical optimization design, reliability design, reverse design, structural topology optimization design, based on additive thinking derived design, etc.

The course candidates of modern design methodology include the students whose undergraduate majors are mechanical engineering and product design. The knowledge base of the course candidates is very different, especially the students majoring in product design, whose core courses are mainly art courses and lack the basic knowledge of mechanical major. However, the knowledge points of this course involve the application of probability theory, advanced mathematics, linear algebra and other knowledge, which is quite difficult for students who have not systematically learned advanced mathematics knowledge in product design major. Therefore, in teaching, in view of the large differences in students' learning basis, explore effective teaching mode to adapt to the learning situation of the course.

3.2 Reconstruction of curriculum knowledge system

The development of modern design methods is fast, but the updating speed of modern design methods teaching materials cannot keep up with the progress of technology. However, enterprises need talents to master the latest design technology. In view of the contradiction between demand and training, the knowledge system of the course needs to be reconstructed. Introduce curriculum ideology and politics, and build a curriculum ideology and politics teaching system that integrates knowledge, ability and emotional goals organically. The knowledge points are deconstructed and reconstructed, and the original chapter knowledge points are replaced by modular knowledge, so as to establish the organic connection between knowledge.

According to the characteristics of the course, the content of the course is divided into two parts, namely design methodology and modern design method. In the chapter of design methodology, mainly teach functional analysis methods, design methods of mechanical systems based on the whole life cycle design process of products. In the chapter of Modern design methods, the basic principles and applications of modern design methods are mainly taught around the latest development of design methods in recent years. Especially the appearance of additive manufacturing technology provides a higher degree of freedom for the design, because any structure can be realized by additive manufacturing, so it provides more choices for the design of mechanical system. Therefore, in the knowledge system of modern design methods, the generative design based on additive thinking and structural topology optimization design are added.

3.3 Teaching Design and teaching strategy

On the basis of reconstructing the curriculum knowledge system and mastering the analysis of learning situation, the teaching design adopts the BOPPPS teaching model, guided by the modern constructivism education concept and following the CDIO/OBE education thought, aiming at enabling students to achieve effective learning. According to the curriculum characteristics of modern design methodology, the teaching adopts the problem-driven teaching method, the whole project teaching as the traction, supplemented by case analysis and the exploration of frontier issues.

Taking the functional analysis method as an example, the pre-class research question "How to achieve mass production of egg yolk and nut in mooncakes" is put forward in combination with the class time around the Mid-Autumn Festival, students are required to complete research and analysis reports. In class, based on the students' research and analysis report, continue to guide the discussion of this problem, thus leading to the concept of functional and functional analysis method. To further explore this problem, it can be abstracted as "separation of yolk and egg white" and "separation of kernel and shell". The functional analysis method is used to realize the above functions, and the functional structure diagram is obtained. On this basis, students are required to summarize the realization method of material separation, and form the solution catalog. According to the project topic selected by students in the first class, based on the knowledge points taught, the project team discussed within the group and questioned between the groups, completed the corresponding design sub-task of the project topic, and realized the internalization of knowledge ability through practice. After class, the students were asked to optimize and analyze the devices of "separation of yolk and egg white" and "separation of kernel and shell" discussed in class.

In terms of classroom teaching organization, 15 minutes (the research finds that 15 minutes is the time when students are highly focused) is taken as the time node to arrange classroom teaching activities. Take a 50-minute class as an example, and its specific classroom organization strategy is shown in Figure 2.

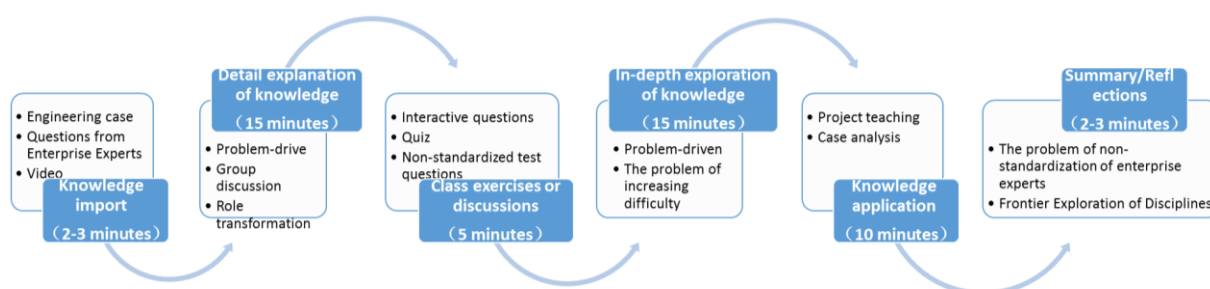


Figure 2 Typical classroom teaching process

3.4 The multiple evaluation

It is necessary to use multiple evaluation methods to evaluate students' achievements in view of the multi-research teaching mode. The method of dynamic process evaluation and terminal evaluation is used to evaluate students' performance and ability in the whole process of learning. Different from the traditional teaching mode, the assessment focuses on the performance of students in the learning process, instead of just relying on the answers in the final papers, which can effectively avoid the phenomenon of students' surprise preparation. According to the learning trajectory data in the learning process, the learning situation of students can be evaluated more objectively and accurately.

The specific multiple evaluation methods are shown in Table 1, in which the results of the homework part of the project are composed of three parts, including student mutual evaluation, enterprise expert evaluation and teacher evaluation.

Table1 The composition of multiple evaluation results

Item	Description	Proportion
Research exploration	Pre-class research report	20%
	Discussion in class	
	After-class research report	
Evaluation in class	Quiz	5%
Experiment in course	Soft program	5%
Project	Creativity	20%
	Feasibility	
	Reliability	
	Team cooperation	
	Presentation	
Exam	Test for theoretical knowledge	50%
	Analysis for practical design problem	
Total		100%

4. The teaching effect of multiple integrated research teaching model

Students' recognition of the course has increased year by year, mainly reflected in two aspects. First, the number of students choosing courses is increasing year by year. Second, the results of students' evaluation of teaching are improving year by year. From the questionnaire survey of students after class, it can be seen that students think that they have gained a lot from the course learning, their personal ability has been significantly improved, and the interaction effect of classroom teaching is good.

In addition, in terms of the quality of submitted papers, the standardization of scientific literature writing has made great progress, and the methods and processes of scientific inquiry have been well mastered. Up to now, this teaching model has been successfully applied to the undergraduate course "Mechanical Design" and the graduate course "Modern Design Methodology".

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