The Application of Scientific Research Cases in the Teaching Process of Mechanical Innovation Design

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Abstract. In view of the difficulty in combining theoretical teaching with practical teaching in the course of mechanical innovation design, the 1+1 teaching mode is adopted to analyze the thinking mode of scientific research and engineering cases in the implementation process, to explain the specific application cases of scientific research and engineering thinking in the process of mechanical innovation design, and to use engineering examples to penetrate the knowledge points to achieve harmony between theory and practice. On this basis, the case question bank and big project question bank of mechanical innovation design were constructed, and the evaluation methods and evaluation criteria of large operation were constructed. The teaching practice proved that this teaching mode conformed to the requirements of innovative talent training and achieved good teaching results.

Introduction

The "Mechanical Innovation Design" course is a comprehensive application of many theories and methods such as theoretical mechanics, material mechanics, mechanical manufacturing, mechanical principles, mechanical design, mechanical innovation techniques, etc. A good carrier for linking these related knowledge and methods to explain is the actual design research (engineering) project. Through the heuristic explanation and analysis based on the actual research project case, on the one hand, good scientific research and engineering thinking mode is demonstrated to students, on the other hand, students can actively think about some problems in the project execution process: Such as the boundary conditions of relevant knowledge in specific applications, the thoughts and considerations of engineers in the process of project execution, etc. Thus, a reasonable logical thinking method and innovative thinking based on the project are developed.

Reform of Teaching Mode

1 + 1 Teaching Mode Based on Case Teaching

The "Mechanical Innovation Design" course of Beijing University of Posts and Telecommunications currently implements the 1+1 teaching mode, specifically: 1 credit hour for theoretical teaching, focusing on concepts, principles and methods; another 1 credit hour for engineering case teaching, through the case of actual scientific research (engineering) projects, the concepts, principles, methods of theoretical teaching and the content related to the prerequisite course are linked in series. Focus on analyzing the premise, ideas and ways of thinking in the implementation of scientific research and engineering projects, pay attention to tell how to apply relevant concepts, principles and methods to carry out innovative design and analysis of practical projects, so that students can feel how scientific research is done without leaving the classroom and learn how engineers think when they do actual engineering projects.

In this course, heuristic teaching and thinking training are carried out on many knowledge points with practical engineering cases, such as "mechanical innovation method," "overall design" and "structural design." At these knowledge points, through appropriate case design, teachers ask students to answer, students ask students to answer, teachers make assumptions, students ask questions and
other forms of classroom interaction are used to analyze the difficulties of the problem from the shallower to the deeper. This interactive mode can clarify the idea of analyzing problem and innovative design to improve students’ ability to solve problems.

Case 1: The solution given by the TV series. When it comes to the three stages of the formation of innovative thinking, a teacher’s research project “Reconstruction of Ni-MH Power Battery Pole Production Line” is taken as an example to illustrate what the teacher was thinking on this project that the American company and the lab were unable to solve, and to explain how he started the analysis from the scene phenomenon and collected the data extensively in view of the problem of uniformity of power battery pole piece coating. When he was puzzled, he suddenly touched a certain bridge in the "Big Dyehouse" TV series one day and was suddenly enlightened. This case fully illustrates the three stages that are indispensable for the innovation process: 1. Preparation stage (long-term accumulation, getting by chance, profound knowledge); 2. Concentrated processing stage (subconscious work); 3. Epiphany stage (Time and time again, I searched for you in the crowd. Suddenly, I spun round and saw the very you standing amidst thin lights).

Figure 1. Case 1: The Solution Given by the TV Series.

Case 2: The application of the work cycle diagram in the overall design of the palletizing robot. When explaining the work cycle diagram, analyze the ideas and methods of a teacher to develop a palletizing robot, explain in detail the design of the palletizing robot and the claws, how to plan and design the working cycle diagram and each item parameters, how to determine the design index and design parameters of the robot according to the parameters of the work cycle diagram, and emphasize the importance of the work cycle diagram in the overall design of the mechanical equipment. This process can be used as a typical case of the application of work cycle diagram.

Case 3: Integral innovative design case for rubber plug installation robot system. Taking a project which designed a rubber plug screwing robot system of a teacher as a case of system integration innovation, and explained the ideas and precautions in the process of industrial robot system integration. Through the case to explain the industrial robot, positioner, pneumatic system and other integrated applications, covering the robot, the non-standard design of mechanical structures, the selection and application of pneumatic components and other related knowledge.
Figure 2. Case 2: The Application of the Work Cycle Diagram in the Overall Design of the Palletizing Robot.

Figure 3. Case 3: Integral Innovative Design Case for Rubber Plug Installation Robot System.

Case 4: Force analysis and structure optimization case of palletizing machine hand claw. Transforming a teacher’s topic of mechanical analysis and optimization of the terminal gripper of the palletizing robot for a robot company in Qingdao into a teaching case. On the one hand, it describes how to use the relevant knowledge of theoretical mechanics, material mechanics, mechanical principles and other courses to carry out the mechanical analysis of palletizing robotic claws. On the other hand, it describes how to use the analysis results and explains the design method and precautions of the palletizing robot’s claws. It is analyzed why a small parameter change can subvert the entire design process under the same mechanism, telling the importance of mechanical analysis to mechanical innovation design and how to apply it.
Through the explanation of these scientific research and engineering cases, many related knowledges can be connected through engineering cases, thus helping students to understand how to conduct scientific research, how to carry out innovative design, and to develop students' scientific research (engineering) thinking, which is conducive to the development of good Innovative design ideas.
Building a Big Project Question Bank for Innovative Design

The "Mechanical Innovation Design" course has its own uniqueness. Its usual results should not be evaluated simply by exercises, but should require the design of certain innovative mechanical devices through various means and methods. Designing innovative mechanical devices in the form of large operations can achieve the purpose of training the comprehensive ability of innovative design to a certain extent. To this end, Beijing University of Posts and Telecommunications has specially built a big project question bank of mechanical innovation design. The total number of questions in the question bank is more than 30. These topics are multi-solutions and not limited, which can train students' comprehensive thinking ability and ability to learn from one to the other through one question with variants, one question with multiple solutions, one question with multiple applications, etc. Students can choose from those topics or draw up their own topics as a usual big project, which account for 40% of the total score.

For the big project of innovative design, students can be allowed to form a group of several people (not more than 4 people), and select a topic in the question bank according to their interests. Each group's report needs to give the design principle, ideas, design basis and method as well as the third-dimensional design. In the end, students who think that their works are excellent can go to the platform to detail their finished works and answer questions from teachers and classmates.

Formulate a Method for Assessing the Performance of the Innovative Big Project

For the results of the innovative big project, the classification evaluation is adopted, that is, the classification scoring is performed according to the situation of each topic reply and report. The main points of scoring are the following:

1. Innovation;
2. Coverage of knowledge and clarity of logical thinking;
3. Use of new technologies;
4. Use of auxiliary design and analysis software;
5. Workload.

In general, the weight coefficient of each of the five aspects is 0.3:0.3:0.1:0.2:0.1. The score does not highlight the workload, that is, it does not advocate achieving good results by workload, but improves the importance of innovation and logical thinking. If one of the five aspects is particularly outstanding, the teacher can appropriately increase the proportion of it. The project score is the average score of this group of students, and each group of students can determine the increase or decrease of the scores of each student in the group according to their respective contributions.

Figure 6. Student Work 1.        Figure 7. Student Work 2.        Figure 8. Student Work 3.
The Teaching Effects

This case heuristic teaching method based on scientific research (engineering) projects focuses on explaining the execution ideas and thinking methods of scientific research or engineering projects, so that students can know how to think about specific engineering problems. After several years of implementation, good teaching results have been achieved, and the most obvious improvement is the students' innovative big projects. Before the implementation of case teaching, the engineering and innovation of big projects are insufficient, and many of them are schematic design of principle, which is far from practical application. After implementation, a number of innovative engineering designs that can be applied for patent can be produced from the annual projects. These changes show that the heuristic teaching based on the case of scientific research (engineering) is a good training for students' innovation and logical thinking mode.

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