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Practice Teaching Reform of Hydraulic and Pneumatic Pressure for Students' Ability Training

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Abstract: Cultivating students' ability is the fundamental task of education, among which students' ability to solve complex engineering problems is an important requirement in engineering education certification. This paper analyzes the characteristics of complex engineering problems and the mapping relationship between them and graduation requirements, and reforms the practice teaching of *Hydraulic and Pneumatic Transmission Course Design*, so that it can better play the supporting role of practice teaching in cultivating students' ability to solve complex engineering problems. First, optimize the teaching objectives of the course, and make them correspond to some indicators of the ability to solve complex engineering problems in the graduation requirements. Then, according to the characteristics of complex engineering problems, the teaching content, teaching design, organization and implementation methods, achievement evaluation and other links are reformed, and a practical teaching solution of curriculum design is formed.

Keywords: complex engineering problems; engineering; professional certification; practice teaching Chinese library classification Number: G642 Document Identification Code: A

1. Introduction

How to make students have the ability to solve complex engineering problems after graduation is the core problem to be solved in educational reform. China's engineering education professional certification has clearly defined the requirements of professional ability, comprehensive quality and social ability that students should have when they graduate (Lin, 2016) for solving complex engineering problems. This task can not be achieved by a single course, and the ability requirements need to be decomposed and implemented. In the whole process of undergraduate education, it is realized by arranging a series of theoretical courses and practical courses. Different types of courses undertake different tasks. Basic courses for majors focus on the cultivation of the ability to identify, express and analyze complex problems, while specialized courses undertake the cultivation of the ability to analyze, design and research. Practical courses require students to comprehensively apply knowledge and methods to solve practical problems(Han & Fang, 2020, Lei et al., 2020). *Hydraulic and Pneumatic Transmission Course Design* is a comprehensive practical course based on hydraulic transmission theory. According to the graduation requirements of engineering certification and the characteristics of complex engineering problems, the teaching objectives of the course are optimized, and the teaching contents, teaching plans, organization and implementation methods, achievement evaluation and other links are reformed and practiced to better cultivate students' practical ability.

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2. The correct understanding of complex engineering problems

China Engineering Education Professional Certification Association defines complex engineering problems. The meanings of complexity and engineering are interpreted with seven characteristics (Yang et al., 2020, Xie et al., 2017). Complexity does not mean high technical difficulty, but more means that complex engineering problems can't be understood as complex technical problems unilaterally without ready-made solutions (Yu & Li, 2019， Geng,et al., 2018). Engineering refers to the practical application, and the cost and economic benefits should be considered in the implementation process. Therefore, in teaching, we can not simply transplant scientific research projects into practical teaching, but introduce practical engineering application projects so that students can get real engineering training. Only by accurately understanding the characteristics and connotations of complex engineering problems and integrating them into the teaching contents and implementation methods of the course can we meet the high-level requirements of the course for the cultivation of students' ability.

3. Curriculum reform and practice

There are eight indicators of professional certification graduation requirements related to solving complex engineering problems. Course Design of Hydraulic and Pneumatic Transmission is a comprehensive practical course, which can share four of them. First, optimize the

course teaching objectives according to the graduation requirements, as shown in Figure 1, and then design the teaching plan.

Teaching objectives	Indexes of graduation requirements
1. Students can comprehend design assignments and analyze the working situation of the hydraulic transmission system to be designed, to confirm the design scheme for the system, and conduct design for parameters, component selections and system calibration.	[2.3] Students shall grasp the theoretical knowledge of their major and be equipped with the ability to analyze complex engineering problems.
2. According to calculation results, students can improve the system scheme, complete to map the schematic diagram of the system, arrange properly the system components, and finish the layout design for hydraulic manifold blocks. Besides, students can finish design for hydraulic manifold blocks and engineering drawing.	[3.1] Based on grasped major knowledge and skills, students can propose solutions to given engineering problems, recognize all kinds of limitations of design assignments, set reasonable technical indexes of designs, and analyze the rationality of their designs.
3. Students work in a group to finish the integral design for a hydraulic manifold block, which enables to cultivate team work among students.	[9.2] Students can take roles in an individual, a member in a group and a leader.
4. Students can describe and explain the design procedures, write the design manual, which develops students' ability of literal expression . In addition, students' presentation can be improved through oral defense.	[10.2] Students can comprehend and write reports and design documents with good application, and deliver effective presentation.

Figure 1 Teaching objectives of the course

Firstly, a complex engineering problem should be selected and designed around the teaching content and teaching objectives, which should not only have practical application background, but also meet the characteristics and requirements of complex engineering problems. Students are required to design the hydraulic system according to the actual engineering requirements. The teaching design process and the corresponding relationship with the teaching objectives are shown in Figure 2.

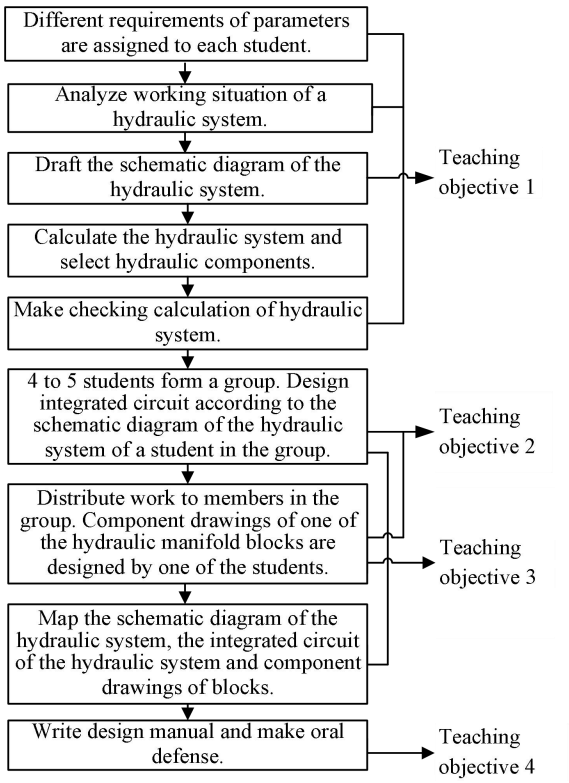

Figure 2 Teaching design process

The task is to design a machine tool hydraulic system according to the actual engineering requirements, and the implementation process is as follows.

3.1 Assign each student complex engineering problems with different working conditions and parameters that need to be solved. With different working conditions and parameters, the pressure and flow required by the system, the applicable oil supply mode and speed regulation mode will be different. This makes the principle of hydraulic system designed by each student different.

3.2 Students analyze the working conditions, formulate the principle of hydraulic system according to the analysis results, and determine the oil supply mode, speed control circuit and sequential action circuit of the hydraulic system. Calculate system parameters and determine the model of hydraulic components.

3.3 Design manifold blocks in groups, select the hydraulic system scheme designed by one member of the group, and design the corresponding hydraulic integrated circuit of the whole group. Each team member is responsible for the part design of an integrated block in the hydraulic integrated circuit. It is required to design the manifold block according to the actual floor size of the selected components, as shown in Figure 3. There is no installation interference, and it is required that all functions of the selected hydraulic system scheme can be completed when the manifold blocks of each layer are assembled together.

3.4 Drawing design drawings, writing design specifications, and defending courses.

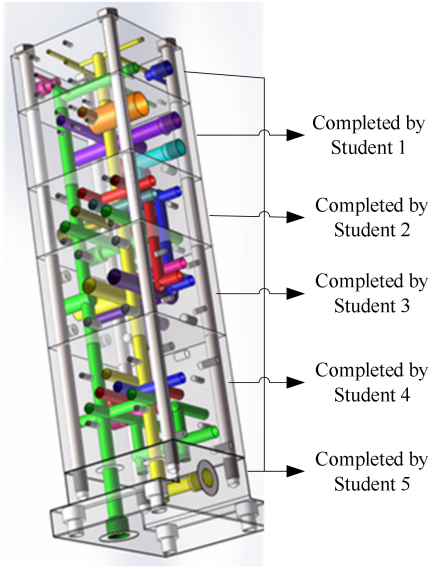

Figure 3 assembly drawing of each manifold block

4. Analysis of characteristics of complex engineering problems

Reform the teaching content and implementation mode of the course. The introduced engineering problems and the implemented teaching scheme meet the four characteristics of 1 plus X characteristics of complex engineering problems, namely, characteristics 1, 3, 4 and 7, and meet the requirements of engineering education professional certification.

4.1 Students need to master the theoretical knowledge of hydraulic transmission before designing. Then, according to the specific design requirements and working parameters, the hydraulic system scheme is designed through analysis and calculation. Taking solving practical engineering problems as the background, students can realize the sublimation from mastering knowledge to applying knowledge. Meet the characteristics of complex engineering problems 1.

4.2 Each student is assigned different engineering parameters, which will lead to different results of working

Process evaluated	Weighting coefficient	Evaluation content	Teaching objective	Indexes of graduation requirements
Analysis of Problematic projects	0.3	Analysis of system working situation; Design and calculation; Checking calculation of changing temperature	1	[2.3]
Design and development	0.4	Scheme design and component selections	2	[3.1]
Communication ability	0.2	Oral defense ability; Writing ability of manual; Drawing ability	4	[10.2]
Team work	0.1	Cooperation of design for blocks	3	[9.1]

Table 1: Final evaluation details

condition analysis and system calculation. In this way, the basic circuit applicable to each link of each student is different, resulting in different hydraulic system principles designed by students. In the design stage of manifold block, students have more room to play freely, and the specific positions of hydraulic components in the integrated circuit are completely designed by students themselves. The design schemes corresponding to different positions are completely different. There is no fixed and unique solution, and students are required to carry out original design. Accord with that characteristic 3 of complex engineering problem.

4.3 In the design, each student is assigned different engineering parameters, and some students will encounter extreme working conditions of super-large pressure and super-large flow rate. The existing problems cannot be solved only by the common hydraulic basic circuit. Students need to break through the thinking patterns of methods and disciplines, and adopt a variety of loop synthesis methods to meet the requirements. Accord with that characteristic 4 of complex engineering problem.

4.4 Design manifold blocks in groups, and the design of each manifold block in the same integrated circuit is interrelated and restricted. Each team member independently completes the part design of an integrated block. Students should handle the relationship between a single integrated block and the whole system. The manifold blocks are required to be placed together, and can be connected with each other according to the hydraulic system design scheme to form a complete hydraulic system circuit. Meet the characteristics of complex engineering problems 7.

5. Analysis of the degree of achievement of curriculum objectives

According to the teaching objectives of the course and the corresponding graduation requirements, the evaluation will be conducted after the end of the teaching. The design process is evaluated from four aspects, as shown in Table 1, and the evaluation weight coefficient is designed according to the supporting relationship of the graduation requirement index points. The examination results of 325 undergraduates majoring in mechanical equipment manufacturing and automation are shown in Table 2.

Analysis of the report on the achievement degree of curriculum objectives shows that the achievement degree of curriculum teaching objectives 1 and 3 is good, while the achievement degree of curriculum teaching objectives 2 and 4 is low. There are three main reasons.

5.1 Introducing complex engineering problems to propose design tasks, with complex working conditions and many requirements. Students' engineering principles are applied to design for a single working condition, and they have a good grasp of it. However, after the working condition requirements are complex, higher requirements are put forward for students' comprehensive analysis ability. Most students' analysis problems are not comprehensive, which leads to many design schemes that need to be optimized.

Process evaluated	Teaching objectives	Score	Average	Reaching evaluation of content examined	Course reaching evaluation
Analysis of Problematic projects	one	15	12.38	0.825	0.825
Design and development	2	40	31.32	0.783	0.783
Communication ability	four	20	15.82	0.791	0.791
Team work	three	10	8.82	0.882	0.882
Total course reaching evaluation					0.783

Table 2: Analysis report on course reaching evaluation

5.2 The manifold block design is diverse and unique. However, in the design process, students' innovative consciousness is not enough, and most of the design schemes are similar to those of reference examples.

5.3 Some students' integrated block parts drawings failed to be drawn strictly according to the engineering drawing requirements.

According to the above reasons, the improvement measures are put forward. In the teaching, the explanation of several comprehensive examples of hydraulic system is added to broaden students' horizons. In the design process, the stage report tracking link is added to improve students' design ability through communication within and outside the group. Increase the content of design scheme simulation verification, and enhance students' understanding of system scheme design. Drawing according to the standard is strictly required to improve students' engineering consciousness and engineering quality.

6. Conclusion

Cultivating students' ability to solve complex engineering problems is the primary task of professional practice course teaching. Combining with the characteristics of complex engineering problems and the requirements of engineering education certification, this paper reformed the teaching content, teaching design, organization and implementation methods and achievement evaluation of *Hydraulic and Pneumatic Transmission Course Design*. Combined with practical engineering cases, the teaching implementation plan of complex engineering problem ability training was given, which made a positive attempt to improve the quality of engineering education, accumulated useful experience, and provided reference for cultivating students' ability to solve complex engineering problems.

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Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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