Research and Practice of the Research—Exploration Curriculum Design Oriented by Practical Innovation Ability

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Abstract. Enterprises' demand for talents with innovative and creative abilities, return of higher education at the national level, and higher education in response to international competition and challenges require universities to increase the cultivation of students' innovative and practical abilities. Curriculum design needs to be reformed in such aspects as training target, guidance methods, performance evaluation, so as to create conditions and environment which are conducive to the cultivation of students' innovative and creative ability. This paper takes the human factor engineering curriculum design as an example, carries on the pattern of research-exploratory curriculum design. The students' interest, practical innovation ability and curriculum design results have been improved greatly. This curriculum design pattern has good application and popularization value.

Introduction

As an important part of cultivating students' practical and innovative ability, curriculum design of undergraduate, especially for engineering and near engineering curriculums, plays an important role. On the one hand, from the point of view of mastering knowledge, curriculum design has practical value in training students to apply the basic principles and methods learned in class to solve practical problems; on the other hand, from the perspective of university practice teaching arrangement, curriculum design is an important part between in-class (extracurricular) experiments and graduation design.

The intermediate link plays the role of “connecting the preceding and the following”. Scientific curriculum design methods and means is one of the important ways to improve students' practical
and innovative ability. This paper proposes to carry out the reform of research-exploratory curriculum design in engineering and near-engineering curriculums, and takes curriculum design of human factor engineering as an example.

Motivation of the Reform Research-Exploration Curriculum Design

Enterprise’s Demand for Practical and Innovative Talents under Uncertain Peripheral Environment

For most industries, they are facing enormous risks and opportunities of increasing uncertainty now and in the future. Accordingly, enterprises have put forward higher requirements for employees’ ability and quality to cope with these uncertainties [1]. Since 2016, Huawei President Ren Zhengfei, Gree Chairman Dong Mingzhu, Lenovo Chairman Liu Chuanzhi and many other industry heavyweights in China have repeatedly said on different occasions that enterprises are facing more and more enormous challenges of uncertainty, and the demand for innovative and creative talents adapting to uncertain changes is greater than ever before.

As the main supplier of high-level labor force, colleges and universities must adapt to this wide variety of talent demand and make corresponding reform and adjustment. Otherwise, students trained under the traditional engineering education model may not be able to meet the needs of the industry, or the transition time to meet the needs after graduation will be long, and the switching costs will be high.

National Higher Education Strategy Requires Practical Education Reform in Universities

In 2017, Ministry of Education of the People’s Republic of China officially launched the Emerging Engineering Education (3E) program, and now, “Fudan University Consensus”, “Tianjin University Movement “, “Beijing Guidance” and other guiding documents have been formed [2]. Under the guidance of 3E, China’s higher engineering education is carrying out comprehensive innovation and reform in the aspects of concept, path, framework and method, so as to improve the competitiveness of higher engineering education in the world.

Facing the change of social demand and the strategic adjustment of national higher engineering education, university teachers should transform the demand for students’ talent and quality into the reform of contents, methods and evaluation in the process of education and teaching. In practice, they should pay more attention to the cultivation of students’ practical innovation ability, especially the ability of solving the problems existing in the research objects by applying basic principles and methods of related disciplines.

The Importance and Major Problems of Engineering Curriculum Design at Present

The order of the main practice parts of engineering undergraduate students is: in-class (extracurricular) experiment—curriculum design—graduation design. Curriculum design is the bridge between in-class (extracurricular) experiment which mainly carries out validation research and graduation design which mainly carries out comprehensive research. On the one hand, curriculum design can not only apply the theoretical knowledge and methods of related curriculums to a specific and complete research object, but also synthesize the scattered experimental research conclusions; on the other hand, curriculum design is actually a small version of “graduation design”. Learning and research habits, mastery of scientific research methods which has been formed well at this stage has a very good “exercise” effect for graduation design.

The main purpose of engineering and near-engineering curriculum design is to train students to apply the basic principles and methods learned in the classroom to solve a practical problem, such as designing a specific device, structure, program, scene.... Taking the human factor engineering curriculum design of domestic universities as an example, we find that there are many problems as follows: (1) the design topic is single, or the scope of design is relatively narrow; (2) the design process is modeled and templated seriously; (3) the evaluation of design results is too much emphasis on the correctness, neglecting the “fantastic” innovation and trial-and-error process.
We know that the research objects’ diversity and uncertainty constraints in the real production and living environment determine that the research results are often uncertain and diverse. Therefore, the traditional curriculum design not only deviates greatly from the actual production and life, but also is not conducive to the cultivation of students' practical and innovative ability.

The Essence, Connotation and Approach of Research-Exploration Curriculum Design

In *A History of the Problems of Education*, John S. Brubacher pointed out that the purpose of education is no longer to store a large amount of knowledge in the mind through memory, but to train and improve the analytical and organizational abilities of the mind, which can then be transferred to any field of human knowledge with the same effect[3]. The famous Boyer Report states that exploration, investigation and discovery are the core of the university, and everyone in the university should be the discoverer, learner, and then establish a research-based learning model[4]. Universities in the 21st century should cultivate students’ “advanced ability” rather than “basic ability” of how much knowledge they have acquired. The so-called “advanced ability” refers to students' learning and innovative skills, including creative and innovative ability, critical thinking and problem solving ability, communication and collaboration ability (Framework for 21st Century Learning) [5].

Thus, it can be seen that the application of relevant theoretical knowledge, dialectical, migratory to solve the object with uncertainty is really embodies to improve students’ “advanced ability”. The reform of research—exploration curriculum design is based on such a starting point, which mainly trains students scientific research methods when facing complex and uncertain problems, cultivates scientific research habits, and improves scientific research and exploration ability.

The essence of research—exploration curriculum design is a kind of model which return to the essence of designing to improve the students' ability of independent practice and innovation. On the premise of not deviating from the overall design goal, it is advocated to diversify the design topics, enhance the exploratory design process, and attach importance to the innovation of design results, so that students can improve the relevant theoretical knowledge from the simple “memorization” level to the “application” level in different scenarios (under uncertain environment). Therefore, the core of research—exploration curriculum design is to turn the problem of “mainly examining and verifying what students know” in traditional curriculum design into “mainly stimulating and guiding students to solve why”. Based on this, the research-exploration curriculum design can be reformed from the following ways.

First, it tries to adopt open and flexible curriculum design topics. On the premise of satisfying the basic principles and methods of investigation, we should try to diversify design subjects and objects. According to the proportion of instructors and students, students can be divided into teams with 2-3 persons or 1 person. Thus it can not only meet the needs of different interests in selecting topics for students, but also effectively avoid the disadvantages of imitation and homogeneity.

Secondly, the time of curriculum design extends to “second classroom” and other extracurricular time. One or two weeks design time in teaching plan can only ensure that students follow the correct methods and ideas for imitative design, there is no more time to give students some “trial and error” exploration. Research—exploration curriculum design can combine limited “in-class teaching plan” with relatively unlimited “second classroom” and other extracurricular time.
Thirdly, in course of curriculum design, the teachers only give limited guidance and try not to deny the students' ideas and methods. They mainly undertake two aspects. One is encouragement, guidance and inspiration. Faced with a relatively complex design topic, students who are accustomed to “follow the instructions” tend to be afraid of difficulties and even feel unable to start. At this time, the teachers should inspire students' confidence and courage. The two is to make proper hints and guidance so as to avoid students to make mistakes in principle and direction. In fact, allowing students to conduct some “trial and error” studies properly can enhance their understanding of the relevant knowledge.

Finally, the evaluation criteria for curriculum design should pay more attention to the value judgment of exploratory research. We should abandon the simple “whether the results are correct” as the main basis for performance evaluation, and adopt a more comprehensive evaluation which can reflect the truly ability of students, which includes inherent logic of the curriculum design instructions, innovation of research methods, comprehensive application ability of other professional curriculums and even interdisciplinary knowledge, and attitude while designing.

Practice Effect of Research—Exploration Curriculum Design

Human factor engineering has the nature of both engineering and social sciences, which determines that its research object has great uncertainty, diversity and complexity under different working conditions. Therefore, its curriculum design must reflect the differences between it and mechanical engineering, chemical engineering, bioengineering and other general engineering disciplines.

According to the above ideas and methods of research-exploratory curriculum design, we have carried out corresponding reform and innovation in practice on two sessions of students in Tianjin University of Science and Technology. We find that compared with previous sessions, there are several gratifying phenomena: students' interest and enthusiasm on participating in curriculum design, students' practical ability to solve problems by applying theoretical knowledge and the quality of curriculum design have been significantly improved respectively, and some students' curriculum result is published in academic journals.

The research-exploratory curriculum design aims at cultivating students' ability to independently discover, analyze, research and solve specific problems in actual production and life. It requires students to experience the twists and turns of scientific exploration following specifications, paths and processes of engineers and technicians, and lays a good foundation for the follow-up graduation
design, future work or further study. This new curriculum design pattern reflects the training function of curriculum design for talents’ practical ability.

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