Transactions on Comparative Education (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/trance.2024.060608
ISSN 2523-5818 Vol. 6 Num. 6

Cultivation of college students' innovative practical ability through the integration of competition and education

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Keywords: Innovative practical ability, mechanical engineering majors, integration of competition and education, outcomes-based Education, CDIO practice project

Abstract: The innovation and practical abilities of college students have been improved through the integration of competition and education at the School of Mechanical Engineering, Qilu University of Technology. Practice has proven that this measure is in line with the national goal of cultivating application-oriented, technically skilled and innovative talents in undergraduate institutions. The integration of competition and education can fully tap into students' innovative potential which is of great significance to both participating students and instructors. The current situation of college students' innovative practical ability has been analyzed. The teaching system under the OBE concept and the multi-level practical teaching links of design courses have been introduced. These practices provide some reference for the cultivation of college students' innovative practical abilities.

1. Introduction

The information age has brought about a new round of scientific and technological revolution and industrial transformation. At the same time, it has put forward new requirements for higher engineering education[1]. How to train high-level innovative talents who can effectively support and serve a series of national strategies such as "innovation driven development", "Made in China 2025" and the "the Belt and Road" initiative has become the main task facing China's current higher education. The cultivation of innovative practical ability among college students majoring in mechanical and electrical engineering has been widely valued by universities and placed in a prominent position in talent cultivation. As an important tool for cultivating students' practical and innovative abilities, subject competitions for college students have made rapid progress in the context of new engineering disciplines[2]. Various universities attach great importance to and encourage college students to participate in subject competitions and have introduced different policies to support them.

However, upon closer inspection of the current state of academic competitions, it is not difficult to find that college students' academic competitions have not yet achieved a deep integration with

professional education[3]. On the one hand, subject competitions are booming, but on the other hand, their support for professional training objectives is clearly insufficient[4]. The integration of subject competitions with professional courses is not close enough and there are no mandatory requirements for students in subject competitions. Participating students cannot achieve full coverage which affects the achievement of training objectives. The insufficient platform resources and imperfect teaching operation system that support subject competitions also affect the organic integration of subject competitions and professional education. With the continuous expansion of the number and scale of subject competitions for college students, how to make subject competitions more effective in serving the training goals of professional talents has become one of the important issues that urgently need to be solved in the current new engineering background for universities to cultivate innovative talents[5].

2. Practical Teaching System under OBE Concept

2.1. Outcomes-based Education

The OBE educational philosophy also known as outcome oriented education, ability oriented education, goal oriented education, or demand-oriented education. The OBE educational philosophy is a result oriented, student-centered and reverse thinking approach to curriculum system construction. It is an advanced educational philosophy and one of the core concepts of engineering education certification[6].

The goal of instructional design and implementation is the learning outcomes that students ultimately achieve through the educational process. OBE emphasizes the following four issues. What learning outcomes do we want students to achieve? Why should students achieve such learning outcomes? How to effectively help students achieve these learning outcomes? How do I know if students have achieved these learning outcomes? The achievement referred to here is the final learning outcome achieved by students, which is the maximum ability that students can achieve after a certain stage of learning[7].

2.2. Multi level practical teaching system

The first and second year of university mainly cultivate three abilities. The first ability is hands-on ability and the ability to use modern tools. The second ability is problem analysis ability and the third ability is the ability to design/develop solutions and plans. These three abilities can be trained through experiments within the course and open innovation experiments. During this period, students can participate in the Mechanical and Electrical Product Innovation Design Competition and the Digital Innovation Design Competition.

The second and third years of college mainly cultivate three abilities, namely project management ability, professional norms awareness, and teamwork ability. These abilities can be trained through the CDIO project. During this period, students can participate in the National Mechanical Innovation Design Competition, Engineering Practice and Innovation Ability Competition, and various robot competitions.

The fourth year of college mainly cultivates three abilities, namely research ability, ability to solve complex engineering problems, and lifelong learning literacy. These three abilities can be trained through graduation design, innovation and entrepreneurship projects, and participation in teachers' research projects. During this period, students can participate in graduation design competitions and innovation and entrepreneurship competitions.

3. Multi level practical teaching in design courses

3.1. Open Innovation Experiment

The experimental project setup should be combined with 3D modeling competitions and suite competitions.The open innovation experimental projects that can be opened include 3D modeling and motion simulation analysis of machines, creative design and production of biomimetic robots, product improvement design experiment based on fischertechnik, mechatronics experiment based on fischertechnik, design and production of wheeled fighting robots, research and innovative design of geometric robots, research and design of cellular mechanisms, design of humanoid combat robot.

3.2. Make full use of the experiments in various professional courses

In the newly revised training program, the proportion of experimental hours for verification has been significantly reduced and comprehensive experiments have been added, accounting for over 75% of the total experimental hours for core courses. The setting of experimental content is combined with the hot topics of mechanical research and their subject competition themes. The evaluation of experimental works mainly includes two aspects. The first is the optimization design and evaluation of mechanisms driven by machine functions. The second is the innovative design and implementation of motion systems for complex machine functions. This project-based practical teaching mode allows students to form teams freely, with 4-5 people in each group. During the experimental process, students are always independent and teachers are always guides.

3.3. CDIO Project Practice in Mechanical Innovation Design and Manufacturing Comprehensive Practice Course

The comprehensive practice of mechanical innovation design and manufacturing is a compulsory course for mechanical engineering students which is a 3-week intensive practical course. There are three main types of experimental projects, technology competition type, innovative experimental type and discipline frontier type. The design task requires innovative design practices with engineering background to complete product design and development according to the steps of "conception-design-implementation-operation". Students are still free to form teams of 4-5 people and can choose from the topics announced by the college. After the course is completed, students can apply for patents or participate in corresponding competitions using the achievements obtained in the course.

The specific implementation steps are as follows. First, the teacher releases the course theme, and students are free to form teams. Then the students registered for the CDIO project and the group members conducted research together to supplement their knowledge. They focused on discussing the preliminary plan and participated in the first defense. The main purpose of the first defense is for the teacher to assist the students in selecting topics and preliminary plans. One week later, the students will have their second defense with the aim of the teacher reviewing their proposal. At the end of the course, students will participate in the defense and excellent works will be recommended to participate in the provincial competition. At the same time, students can apply for the completion of the CDIO project and 2-3 selected works will be recommended to participate in the national competition.

Some of the students' works have unique functions and are the only ones in the whole class. Some have reliable performance and have achieved excellent performance through institutional innovation. Some have adopted reasonable and even clever designs, while others are interdisciplinary and have achieved the transformation of results. Some have good application

backgrounds. Some have adopted cutting-edge technology and achieved a high level.

When participating in the National Machinery Product Innovation Design Competition, students introduced the research and development process based on product evolution. Firstly, they determine the product functions based on the requirements, consult patents and related products in the market, determine the product plan, make principle models, design parts, process and debug. The Intelligent Fighting Robot Competition mainly cultivates students' ability to design and produce stable performance works. By repeatedly testing and continuously improving standards, the performance of robots can be enhanced.

4. Practical teaching effectiveness

Guided by the cultivation of students' abilities, we set up teaching content and links carefully and improve them continuously. As a result, students' innovative design abilities have greatly improved and the coverage of subject competitions is wide with the number of awards constantly increasing. The guiding teachers learned advanced teaching concepts and methods and keep up with the technological development of the times. They actively participate in various teaching seminars, competition theme analysis meetings and exchange with sister universities. Some of the national level competitions that students participated in the course of four years include national college students' mechanical innovation design competition, college student engineering practice and innovation ability competition, national college students' energy conservation and emission reduction social practice competition, China university intelligent robot creative competition, China intelligent fighting robot competition, national 3D digital innovation design competition.

By participating in these competitions, students not only made physical objects but also innovated their institutions and had great creativity. This is the result of multi-level practical teaching support.

5. Conclusions

Combining curriculum teaching with extracurricular competitions can combine education with entertainment thereby stimulating students' interest. By closely integrating comprehensive experiments and the theme of mechanical innovation design competitions, the content and difficulty of experiments within the course have been enriched and students' interest in mechanical innovation design has been enhanced. The teaching method of "strictly selecting topics, decomposing tasks, supervising the process, deliberately practicing, and improving performance" greatly enhanced the performance of works and cultivated students' mechanical innovation design ability. In the future, we will actively strengthen students' entrepreneurial awareness and gradually form an atmosphere that shifts from "innovation ability cultivation" to "entrepreneurial goal orientation".

Acknowledgements

This work was financially supported by research project of Qilu University of technology (0412021232), integration of industry and education and collaborative education project of the ministry of education (220600805242635), Shandong Province Undergraduate Teaching Reform Research Project (M2023246).

References

[1] Yin Dongsong, Liang Weizhong, Shi Wenqing, Design of quality education based on the cultivation of college students' innovation and practical abilities [J]. Journal of Social Science of Jiamusi University, 2024, 42 (06): 131-132+135.

[2] Li Yan, Zhang Jing, Wang Xiong, Cultivation and practice of college students' innovation ability under the five music education model [J]. Tech Wind, 2024, (32): 63-65.
[3] He Bo, Yang Guang, Qin Lanyun, Exploration on the collaborative cultivation of scientific thinking and practical innovation ability among students majoring in new engineering [J]. Mechanical Design, 2024, 41 (11): 192-198.DOI: 0.13841/j.cnki.jxsj.2024.11.026.
[4] Mao Lutian, Wang Chunling, Wang Yanjun, Practice of integration of "Internet plus" innovation and entrepreneurship competition and microbiology course competition and teaching in the context of professional innovation integration [J]. Microbiology Bulletin, 2024, 51 (10): 4292-4304
[5] Li Xiaoru, Duan Zhenxia, Wu Enqi, Reform of practical course teaching mode based on the integration of competition and education [J]. Theoretical Research and Practice of Innovation and Entrepreneurship, 2024, 7 (17): 142-144.
[6] Lu Qianqian, Zhou Zhaofeng, Reform of the course "Mechanical Design Fundamentals Practice" that integrates education and competition to educate all students[J]. Southern Agricultural Machinery, 2024, 55 (10): 165-168
[7] Ji Jianping, Tu Chenggang, Qin Yezhi. Reform of the practical teaching mode of "promoting teaching through competition and integrating competition and teaching"[J]. Agricultural Machinery Use and Maintenance, 2024, (04): 156-158.