Advances in Educational Technology and Psychology (2021) 5: 106-114
Clausius Scientific Press, Canada
DOI: 10.23977/aetp.2021.52018
ISSN 2371-9400

Exploration of Extracurricular Practice Teaching Mode of Mechanical Innovative Design Based on OBE Concept

Junbin Lou*, Qing Ouyang

School of Information Science and Engineering, Jiaxing University, Jiaxing 314033 China
**corresponding author: Junbin Lou*

Keywords: OBE concept, extracurricular practice teaching, mechanical innovative design

Abstract: In order to better arouse students' interest in mechanical innovative design, improve students' practical ability and innovative ability, and further enhance the competitiveness of mechanical major students, this paper explores the extracurricular practical teaching mode of mechanical innovation based on OBE concept. The training scheme is formulated from five aspects: training mechanism, training mode, curriculum system, scientific research and training system and quality assurance system. A modular curriculum system is constructed to improve students' hard and soft abilities. Project cases of mechanical innovative design training, such as perforated water pipe puncher and carbon-free trolley design, are developed, which enables students to get the whole process ability training from design, manufacturing and evaluation. Finally, the paper established a diversified evaluation system, and inspected the effectiveness of the extracurricular practice teaching mode of mechanical innovation based on OBE concept from many aspects, which greatly improved students' comprehensive engineering literacy.

1. Introduction

In recent years, the digitalization of manufacturing industries, such as manufacturing innovation center [1], intelligent manufacturing [2] and green manufacturing [3], is advancing comprehensively. By June 2020, the number of enterprises applying digital and information integration management system has exceeded 28,000, the penetration rate of digital research and development of enterprises has reached 71.5%, and the numerical control rate of key processes has reached 51.1%. Digital transformation has become a broad consensus among various industries, and information technology has accelerated its penetration, integration and application in the whole process and industry chain, and the core competitiveness of manufacturing industry has been continuously improved [4-6].

China's traditional manufacturing industry mainly focuses on labor-intensive manufacturing and processing, and gains profits through low value-added manufacturing and cost reduction [7-8]. However, in the face of the current international competitive environment and the new pattern of dual-cycle economic development, such extensive production mode can no longer meet the

development needs of enterprises in the new period. It has become a new breakthrough point for enterprises to form unique competitive advantages by independent innovation design and seek new market opportunities by building differentiated brand image. In the 21st century, the competition of machinery manufacturing industry largely depends on the training mode competition of innovative, applied and compound talents.

In order to meet the needs of the society and further enhance the competitiveness of students majoring in machinery, many colleges and universities have built a mechanical innovation curriculum system. However, the traditional teaching methods are often questioned because of the lack of clear and visual teaching objectives. Many teachers and students are not clear about the four-year study goal of the university. In addition, the social evaluation system based on score theory and the ideological tendency towards utilitarianism lead students to focus only on the study and examination of courses. Traditional education adopts the final evaluation mode of "homework-examination-scoring" as the main evaluation method, which focuses on the understanding and mastery of assessment knowledge, but does not pay attention to the study and comprehensive application of knowledge. How to ensure that the course teaching and examination process are mutually confirmed and interrelated, how to arouse students' interest in mechanical innovative design, and how to improve students' practical ability and innovative ability are urgent problems to be solved.

The education model based on outcome-based education (OBE) [9] was put forward by Spady and others in 1981, and it has been recognized as an effective way to pursue excellent education, and has been paid attention to by famous universities all over the world, especially in the United States, Britain, Canada and other countries, which has become the mainstream educational reform concept. The Ministry of Education emphasizes in the “National Standard for Teaching Quality of Undergraduate Specialty in Ordinary Colleges and Universities” that the evaluation of undergraduate specialty education quality should emphasize student-centered, output-oriented and continuous improvement, which also mentions the importance of OBE concept. From the beginning, the OBE education model has made clear the ultimate learning goal and achievement of students, that is, to cultivate students' comprehensive ability to adapt to the future society. In this paper, we construct the extracurricular practice teaching mode of mechanical innovation based on the OBE concept, which enables students not only to comprehensively apply relevant mechanical design theoretical knowledge and combine innovative ideas to complete the structural design of complex products, but also to improve students' comprehensive engineering literacy.

2. OBE Educational Concept

OBE educational concept has four key points, as shown in Figure 1: (1) Determining learning outcomes. Learning outcomes should be clearly expressed and directly or indirectly evaluated. The requirements and expectations of educational stakeholders should be fully considered when determining learning outcomes. (2) Constructing the curriculum system. Learning achievement represents a kind of ability structure, and the construction of curriculum system is particularly important to achieve learning achievement. There should be a clear mapping relationship between the capability structure and the curriculum system structure, and each capability in the capability structure should be supported by a clear curriculum. (3) Determine the teaching strategy. OBE pays special attention to what students have learned instead of what teachers have taught, the output of teaching process instead of its input, research-based teaching mode instead of instilling teaching mode, personalized teaching instead of "carriage" teaching. (4) Self-reference evaluation. OBE's teaching evaluation focuses on learning achievements, not on teaching contents, learning time and learning methods. Using multiple and hierarchical evaluation criteria, the evaluation emphasizes the

connotation of learning achievement and individual learning progress, and does not emphasize the comparison among students.

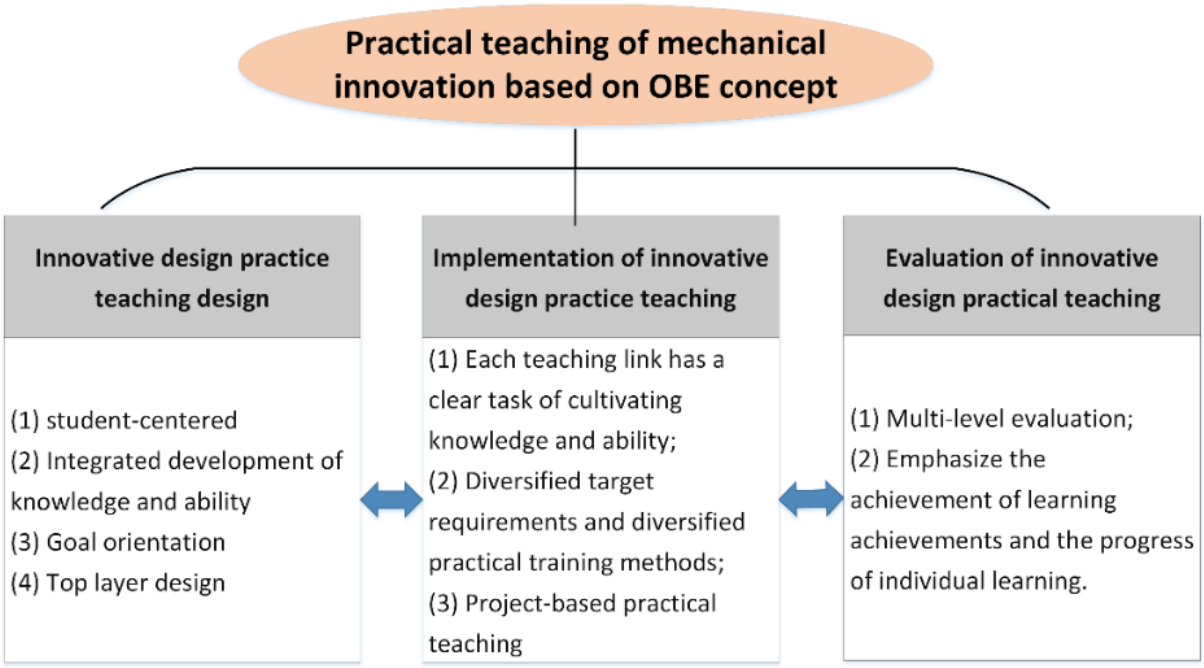

Figure 1: Schematic diagram of practical teaching of mechanical innovation based on OBE concept.

3. OBE-based Extracurricular Practice Teaching of Mechanical Innovation

Mechanical innovative talents should have innovative consciousness, innovative thinking, innovative skills and innovative personality. Therefore, in order to train students' creative thinking and transferable skills, based on OBE concept, the training scheme of mechanical innovative talents is systematically designed, the modular and situational scientific research literacy training is constructed, and the unique extracurricular practice teaching mode is constructed. And an extracurricular practice training system for teaching and learning in exploring knowledge problems, meaning problems, relationship problems between things, evaluation problems and complex engineering problems of mechanical engineering is proposed.

3.1. Teaching Goal

In-class practice teaching mainly emphasizes "basicity, knowledge and application", while extracurricular practice teaching highlights "creativity, exploration and research". Extracurricular practice teaching is similar to the extension of classroom teaching, which enables students not only to acquire basic professional skills, but also to give full play to their own subjective initiative and stimulate their inner creativity and exploration, so as to comprehensively improve students' autonomous learning ability.

3.2. Construction of Teaching System

3.2.1. Training Plan

The systematic extracurricular practice teaching training scheme includes five aspects: training mechanism, training mode, curriculum system, scientific research and training system and quality assurance system, as shown in Figure 2.

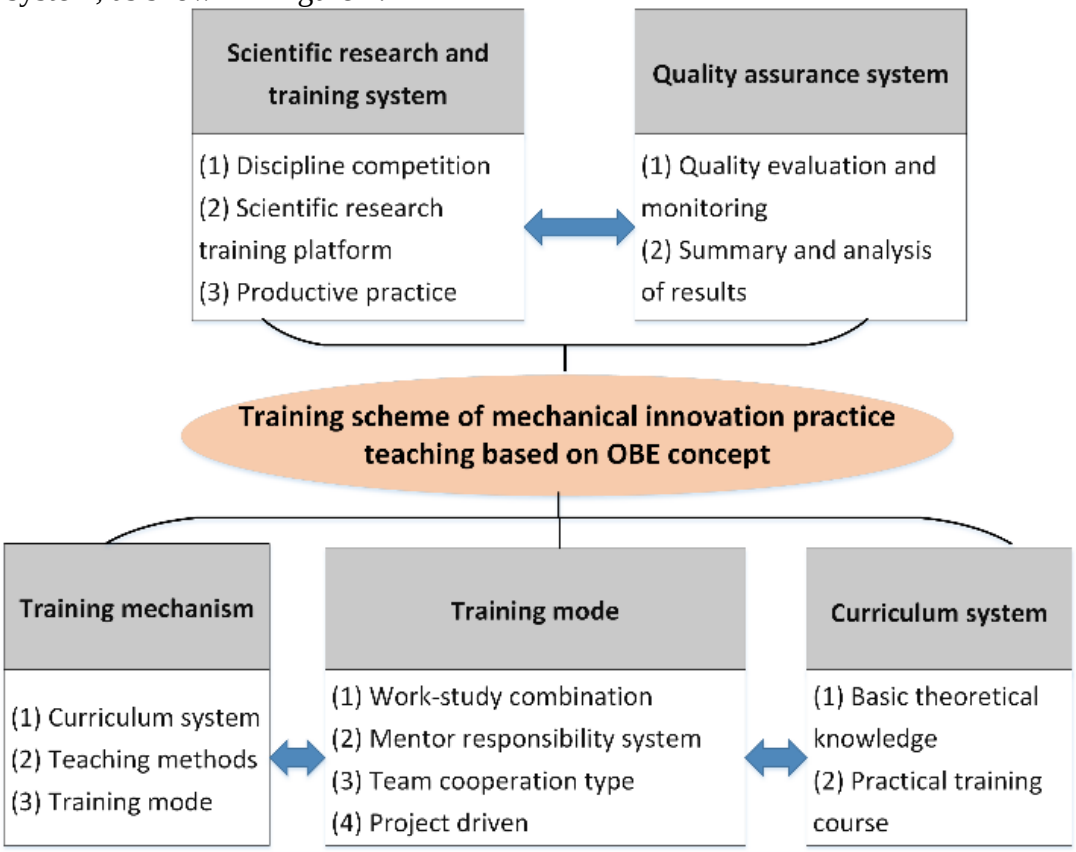

Figure 2: Extracurricular practice teaching training scheme.

3.2.2. Modular Curriculum System

How to make students apply what they have learned and improve their ability to solve complex engineering problems is one of the difficulties and keys to achieve the goal of training engineering talents. The ability to solve complex engineering problems consists of hard ability and soft ability. Hard abilities includes: engineering intelligence, engineering practice ability and engineering innovation ability. Soft ability includes: humanistic quality, engineering ethics, team consciousness, and adaptability and so on, as shown in Table 1.

Specifically, we expand our extracurricular practical research projects such as science and technology competition, innovation and entrepreneurship training programs for college students, and teachers' scientific research, so that students can comprehensively apply interdisciplinary knowledge to solve a practical complex engineering problem and improve their hard and soft engineering ability to solve complex engineering problems.

Table 1: Comprehensive ability and quality of college students.

Comprehensive ability		Specific abilities	(1)	(2)	(3)
	Hard ability	Engineering theory knowledge	Basic knowledge of mathematics and physics	Professional basic knowledge	Comprehensive foreign language ability

		Engineering practice ability	Extracurricular practical training	Enterprise engineering training	Graduation project
		Engineering innovation ability	Discipline competition	Innovation and entrepreneurship training program for college students	Teachers' practical research projects
	Soft ability	Humanistic quality			
		Engineering ethics			
		Team consciousness			

3.2.3. Tutorial System of Extracurricular Practice Teaching

Based on OBE concept, mechanical innovation practice teaching has formed a progressive teaching system of "basic-innovative-comprehensive", which is composed of three modules: "on-campus practice course", "scientific research practice platform" and "off-campus practice base", and has implemented "tutorial system" in cultivating innovative talents.

3.3. Project Teaching Case Development

The purpose of exploring the extracurricular practice teaching mode of mechanical innovation based on OBE concept is to establish a whole chain integrated training scheme of "project creativity-mechanical structure design-mechanical device processing-product". Specific implementation methods: based on the theoretical knowledge of mechatronics, mastering mechatronics engineering technology as a means, taking the development of mechatronics products as the curriculum achievement, and combining with the practical teaching content of "hierarchical, phased and modular" in innovative education system design, carry out the difficulty progressive training of "simple parts to complex mechatronics products", carry out the time period extension training of "centralized to decentralized", and carry out the modular expansion training of "structural design and processing to control system design and production"

Case 1: Based on the application advantages of porous water pipes such as improving irrigation efficiency and saving water resources, a new design scheme of porous water pipes is proposed to improve the production efficiency and drilling efficiency of porous water pipes. The project needs to combine the basic knowledge of mechanical principle, mechanical design and pneumatic transmission, and realize the automatic punching and bunching functions of the device through pneumatic actuation, screw transmission and belt transmission.

Overall structural design as shown in Figure 3：

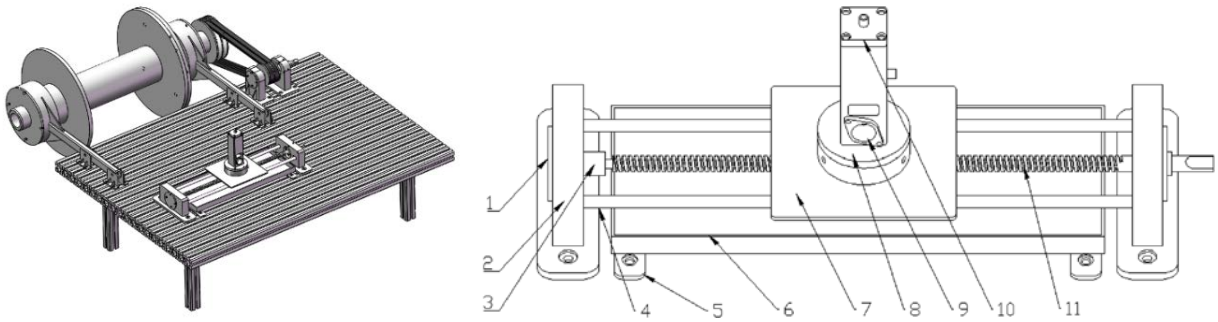

Figure 3: Overall structural design in Case 1.

Case 2: Design of carbon-free trolley with "S-ring" trajectory. This project originated from the comprehensive ability competition project of engineering training for college students in Zhejiang

Province. The project requires students to independently design and manufacture a self-propelled trolley with direction control function, and requires its power source to come from the gravitational potential energy provided by weights, and reasonably design institutions to control the direction and walk out of the required track. As shown in Figure 4, the closed "S-ring" track is composed of straight sections and circular sections. It is required that the trolley can bypass the obstacle piles on the track in turn by the "S-ring" route on the ring track and move forward automatically until it stops. The designed trolley mainly includes winding mechanism, transmission mechanism, steering mechanism and frame structure. This project mainly investigates students' ability to comprehensively apply the basic knowledge of mechanical design, and combine with 3D printing technology to process and manufacture device structures. Realize the ability training of the whole process of design-mechanic manufacturing-evaluation.

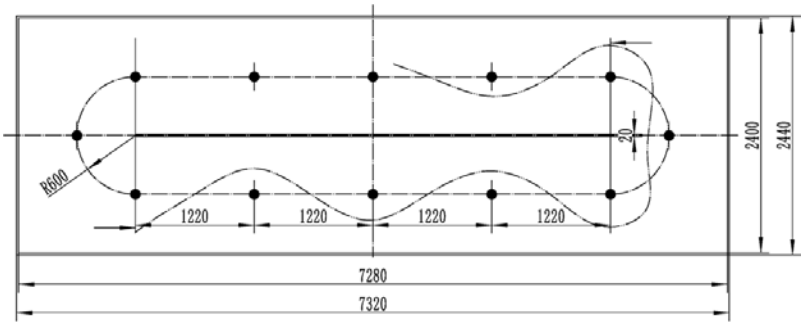

Figure 4: Running track of carbon-free trolley.

4. Construction of Assessment and Evaluation System

In order to promote the improvement of students' core competence of mechanical innovation, a diversified assessment system is adopted to examine students' abilities in a "whole process and all-round" way. We set a number of assessment indicators in the two dimensions of learning process and achievement of results, as shown in Figure 5, and pay attention to students' knowledge and skills, process and methods, emotional attitudes and values, that is, while examining students' knowledge acquisition and intelligence improvement, we also evaluate their innovative consciousness, engineering practice ability, ability to analyze and solve problems, teamwork spirit and coordination ability. Besides teachers, students are also the main body of evaluation. According to the assessment content, different evaluation methods are adopted, including works evaluation, students' self-evaluation, group mutual evaluation and observation interview. Under the guidance of OBE education model, this diversified assessment system focuses on monitoring and evaluating the learning process, training and testing students' comprehensive ability, and paying more attention to the guiding role of assessment in learning.

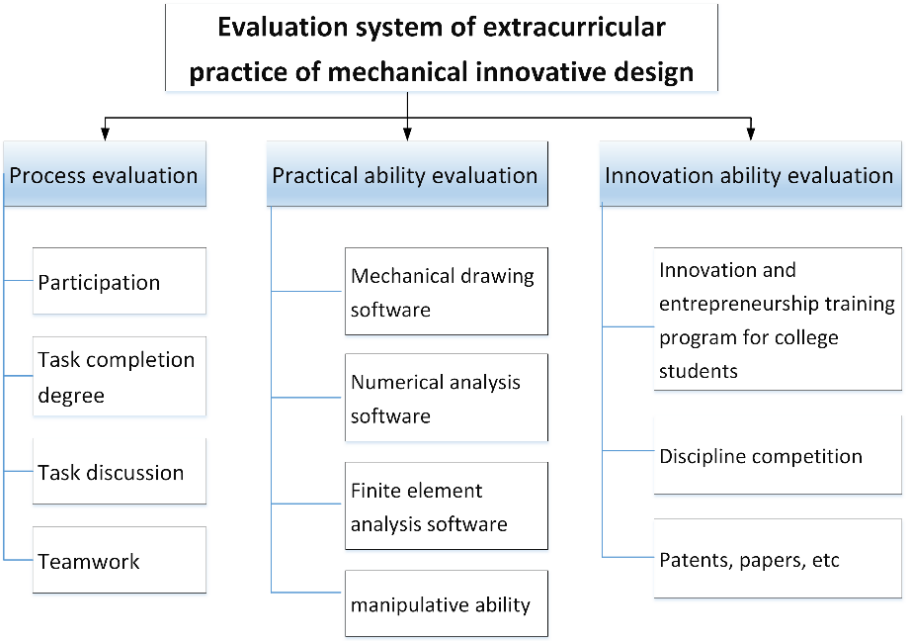

Figure 5: Assessment and evaluation system of extracurricular practice.

5. Training Achievements of Mechanical Innovation Extracurricular Practice

5.1. Improvement of Engineering Quality

Through the extracurricular practice training of mechanical innovation, students can deepen their understanding of design theory and master the necessary engineering application software for mechanical innovation design. At the same time, in the process of processing and manufacturing the designed devices, students can deeply understand the similarities and differences between theoretical design and engineering manufacturing. For example, in the Case 2, the students use Solidworks software to design the device structure, as shown in Figure 6, and then determine the processing technology according to the structural characteristics of the car. For the parts with complex structure which cannot be processed by traditional machine tools or the auxiliary parts which have little influence on the running accuracy of the carbon-free car, 3D printing processing technology is selected for processing and manufacturing. The rear wheel and other structures are processed by CNC milling machine; Gears are machined by wire cutting machine; the rotation axis is manually operated by a numerical control lathe. Standard parts such as knob plungers, fine adjustment screws and bolts, nuts and bearings are independently selected and purchased.

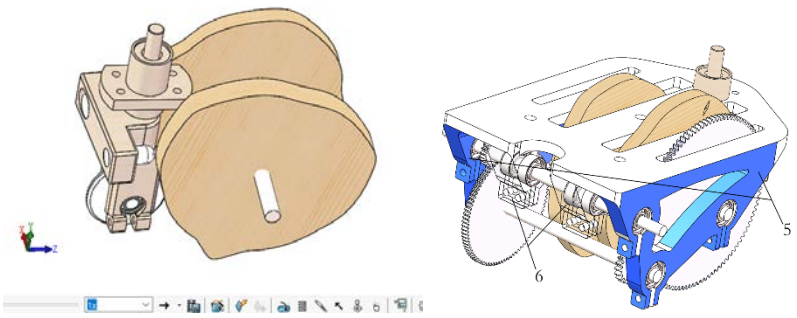

Figure 6: Structural design with Solidworks software.

5.2. Training Achievements

The implementation of OBE-based extracurricular practice teaching mode of mechanical innovation encourages students to actively participate in extracurricular practice activities related to mechanical innovation, such as high-level discipline competitions, college students' innovation and entrepreneurship training programs, and teachers' extracurricular scientific research teams, so as to fulfill the requirements of the project and realize the effects of integrating theory and practice and promoting each other.

In 2019-2020, students from the School of Mechanical and Electrical Engineering of Jiaxing University applied for 9 national innovation and entrepreneurship training projects, 4 provincial science and technology projects, and 31 school-level science and technology projects. A total of 109 person-times were won, including the 12th “Higher Education Cup” National College Students Advanced Mapping Technology and Product Information Modeling Innovation Competition, the 4th Zhejiang College Students Robot Competition, the National NXP Cup Smart Car Competition and the Zhejiang College Students Mechanical Design Competition, and 30 patents and software copyrights were granted by the first inventor of the students, and 16 scientific papers were published. On the whole, through the above-mentioned extracurricular practice of mechanical innovation, students' ability to solve practical engineering problems is improved, and students' awareness of innovation and entrepreneurship is stimulated.

6. Conclusions

The OBE-based extracurricular practice teaching mode of mechanical innovation is results-oriented, focusing on cultivating students’ practical ability, which is different from the “score-only” traditional teaching mode. This paper constructs the training scheme of mechanical innovation practice under the new teaching mode, and stimulates students’ interest in learning mechanical innovation design through project case design, so that students are familiar with the methods of mechanical innovation design and have the basic ability of developing mechanical and electrical products. The training results show that the extracurricular practice teaching of mechanical innovation based on OBE concept has achieved good teaching effect.

Acknowledgements

This work was supported by the Research Project of Teaching Reform funded by the Jiaxing University under Grant 85152004.

References

[1] Ding, M. L., Chen, B. M., Lv, Y. (2016) Research on the Building of the Chinese National Manufacturing Innovation Center based on the Industrial Technology Alliances. 35th Chinese Control Conference (CCC). IEEE.

[2] Zhong, R. Y., Xun, X., Klotz, E. and Newman, S. T. (2017) Intelligent Manufacturing in the Context of Industry 4.0: A Review. Engineering, 3, 616-630.

[3] Bülent, S.and Çankayab, S.Y. (2013) Effects of Green Manufacturing and Eco-innovation on Sustainability Performance. Procedia - Social and Behavioral Sciences, 99, 154-163.

[4] Zolait, A.H., Ibrahim, A.R., Chandran, V. and Veera, P. (2010) Supply Chain Integration: An Empirical Study on Manufacturing Industry in Malaysia. Journal of Systems & Information Technology, 12, 210-221.

[5] Mo, J. (2009) The Role of Lean in the Application of Information Technology to Manufacturing. Computers in Industry, 60, 266-276.

[6] Luo, T., Li, G. and Yu, N. (2019) Research on Manufacturing Productivity Based on Improved Genetic Algorithms under Internet Information Technology. Concurrency and Computation: Practice and Experience, 31, 1-8.

[7] Hanson, G. H. (2020) Who Will Fill China's Shoes? The Global Evolution of Labor-Intensive Manufacturing. NBER Working Papers.
[8] Thorbecke, W. and Zhang, H. The Effect of Exchange Rate Changes on China's Labor-Intensive Manufacturing Exports. Pacific Economic Review, 14, 398-409.
[9] Dai, H.N., Wei, W., Wang, H. and Wong T.L. (2017) Impact of Outcome-based Education on Software Engineering Teaching: A case Study. IEEE International Conference on Teaching.