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Teaching Reform of Mechanical Productive Practice Course for Outstanding Engineers Training

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Abstract: The cultivation of outstanding engineers puts forward further requirements for the students' practical engineering ability. As a key practical course in the field of Mechanical Engineering (ME), the "Productive Practice" course plays an important role in cultivating students' professional practical abilities and comprehensive qualities. This paper proposes teaching research and reform of the Mechanical Productive Practice course based on the new requirements of cultivating outstanding engineers for practical courses. With the teaching reform methodology and implementation in aspects such as the integration of professional theory and practice courses, the practice platforms design considering both internal and external, the combination of virtual and real productive practice, and the optimization of the course process assessment system. The aim is to comprehensively enhance the quality of engineering education through improving internship models and optimizing assessment methods.

1. Introduction

To cultivate a large number of high-quality engineering and technical talents with strong innovative abilities and adaptability, the Chinese Ministry of Education launched the " Outline of the National Program for Medium and Long term Education Reform and Development (2010-2020)", and has placed particular emphasis on promoting the "Excellent Engineer Education and Training Program", aiming to comprehensively enhance the quality of engineering education [1]. The cultivation of excellent engineers has imposed new requirements on universities, teachers, and curriculum instruction.

Constructing a practical teaching system for the "Excellent Engineer Education Training Program" plays an important role in comprehensively understanding the implementation of the Program [2]. There is a need for a significant breakthrough in practical teaching, as it constitutes a crucial link in the cultivation of excellent engineers. It plays a vital role in nurturing innovative and potential-leading engineering talents. Particularly within the current educational framework, students require practical hands-on skills in engineering to bridge the gap between academic learning and employment [3]. Viewed from the perspective of domestic scholars, practical teaching is categorized into four major

modules including experimental teaching, innovation/entrepreneurship projects, practical internships, and graduation projects; while in some other education systems, practical teaching is divided into basic practice, professional practice, and innovative practice. Anyway, professional internships (Productive Practices) are essential modules in cultivating students' professional practical abilities.

As a key component in cultivating engineering thinking in mechanical engineering, the Productive Practices course also serves as a crucial platform for students to engage with companies [4]. At the University of Shanghai for Science and Technology, the major of Mechanical Design and Manufacturing and Automation aims to cultivate engineering-oriented, innovative, and globally-minded talents. The "Productive Practice" course, tailored to meet the needs of the manufacturing industry, collaborates with manufacturing enterprises such as Shanghai Electric Power Generation Equipment Co., Ltd. Turbine Plant, Shanghai Machine Tool Works Ltd., Shanghai Tool Factory, and Shanghai New Power Automotive Technology Co., Ltd. It covers key sectors of the manufacturing industry chain such as component manufacturing, machine assembly, product research and development. By immersing students directly into the frontline production of typical mechanical manufacturing enterprises, the course provides students with profound insights into production organization, enterprise management, and resource planning within mechanical manufacturing enterprises [5].

However, the two-week Productive Practice faces several challenges, such as insufficient depth in the internship process and limited hands-on experience for students. To address these issues and focus on the cultivation of outstanding engineers, it is essential to undertake comprehensive project-based teaching reforms in the course. Based on the typical manufacturing enterprise internships, this paper suggests the integration of professional theory and practice courses incorporating pre-internship expert lectures and post-internship case discussions and further explores the implementation of comprehensive Productive Practices through on-campus platforms and virtual simulations, finally optimizing of the course process assessment system to enhance students' innovation and entrepreneurship capabilities. By teaching reform methodology and implementation, the effectiveness of practical teaching can be improved, facilitating greater integration between theoretical knowledge and practical production.

2. Overall teaching segments and the support for engineering education

To achieve the desired outcomes of cultivating outstanding engineers, the Productive Practice course adopts a student-centered approach, where students are organized into small groups and directly immerse themselves in the typical mechanical manufacturing enterprises. This hands-on experience is complemented by supplementary materials such as online videos and classroom lectures, creating a blended learning environment that combines both online and offline modes. This approach ensures that through the internship experience, students gain a profound understanding of various aspects of mechanical manufacturing enterprises.

To address the numerical requirements of engineers, specific teaching objectives are outlined for this course, and corresponding instructional components are designed as shown in Table 1.

Table 1: Teaching segments for engineering education

Engineers requirement	Program objective	Teaching segments
Taking into account various constraints such as societal, environmental, health, safety, and cultural factors, the feasibility of solutions is evaluated and substantiated.	Understanding the production organization and enterprise management, grasping the basic principles of production organization and management, and being able to consider various constraints in the production process to develop production management plans.	Utilize methods such as case studies of production scenarios, post-class materials study, and internship reports to familiarize students with the production organization and enterprise management of mechanical manufacturing enterprises.
The societal, health, safety, legal, and cultural impacts of engineering projects can be analyzed and evaluated, and appropriate measures should be to employed to mitigate or avoid their adverse effects.	Understand various issues encountered by enterprises in solving practical mechanical engineering problems, fully recognize the engineering background and social responsibilities of enterprises, and grasp the professional qualities and occupational norms.	Utilize methods such as enterprise visits and lectures, surveys on current enterprise development status, and internship reports to guide students in analyzing and evaluating the social, health, safety, legal, and cultural impacts of engineering projects.
The capacity to effectively fulfill individual roles within a team, as well as to organize, coordinate, or lead team activities.	Demonstrate the ability to play individual and team roles effectively through group discussions with enterprise experts, and other activities. Identify and address issues and apply specialized knowledge correctly to various practical engineering problems.	Utilize methods such as enterprise project work based on hands-on practice and report summaries, Combine practical issues faced by enterprises with group learning and interactive discussions among students, engineers, and teachers.
Understanding the necessity of self-directed learning as well as lifelong learning, and putting in action and effort.	Develop awareness and abilities for independent learning and lifelong learning by exploring various manufacturing processes through literature searches, questionnaires, expert interviews, and other methods.	Utilize methods such as literature searches, surveys, discussions, and presentations with enterprise experts to understand the characteristics and principles of various engineering production processes.

3. Teaching reform methodology and implementation

3.1. Integration of professional theory and practice courses based on double tutorial system

At present, due to technological security, fierce market competition, and other factors, it is difficult for college teachers and students to carry out practical activities in enterprises [6]. The traditional professional Productive Practice courses primarily focused on enterprise production cases, leading to a lack of direct connection between theoretical knowledge and industrial production. To address this, adopting a school-and-enterprise double tutorial system involving both on-campus teachers and off-

campus industry tutors is necessary. The on-campus teachers possess theoretical foundations but often lack practical engineering experience, while industry engineer tutors may lack a systematic understanding of the knowledge students are learning. By employing both on-campus and off-campus tutors, students can align theoretical knowledge from academic courses with practical experiences in industry settings.

3.2. Design and implementation of campus practice platforms considering enterprise case

The core goal of the excellent engineering program is to improve the quality of engineering and technical personnel training, which involves the exercise of practical ability. However, due to the large number of students participating in the current practice courses, the busy production of enterprises, and the high safety requirements, students cannot participate in the practice environment in an all-around way. Based on deepening the ' integration of production and education, school-enterprise cooperation ', it is necessary to build an on-campus course practice platform in combination with typical production processes, concentrate on digging deep into the key elements of enterprise production cases, and find innovative points and breakthrough points in the aspects of visiting practice, key points review, hands-on practice, etc. Through the mapping and reproduction of the on-campus experimental platform, each student has a full sense of participation and truly lets students learn something and learn something.

3.3. Practical means combining real and virtual production internships

With the rapid development of virtual reality (VR) technology, its application in higher education has attracted increasing attention [7]. Intelligent manufacturing is also an important part of the Productive Practice course. To fully experience professional skills and intelligence achievement, it is necessary to combine the actual production process with digital media and virtual simulation practice. Based on the factory production and manufacturing process observed by students, the key information of the case is recorded, and the practical operation of parts processing in the virtual environment can be conducted. Combining real and virtual production internships, students can master the operation process of processing equipment like engineers. Furthermore, without safety and cost problems, it is effective to apply specialized knowledge correctly to various practical engineering problem, cultivating the students' autonomous learning ability and enhancing the students' innovative and creative ability. This practical means reform can enable students to master the design modelling, processing and manufacturing, detection analysis, and application methods of parts production, to develop independent learning and innovation ability.

3.4. Optimization of course process assessment system for outstanding engineers training

The training of outstanding engineers should fully combine the requirements of enterprises for engineers, and the course process assessment system should be improved for outstanding engineers’ training. The goal of the course is to develop students’ knowledge, ability and quality. Based on this, methods such as literature searches and surveys, enterprise visits and lectures, case/project studies of production, and internship reports are adopted. Furthermore, the paper explores the optimization of the assessment system of practical courses, including practice participation, practice performance, practice notes, practice content thinking, and other forms. The process assessment system evaluates the production practice process from different angles, supporting the training of outstanding engineers. Through the integration of various forms of process assessment, the students' learning effect is reflected from the aspects of design and development solutions, engineering and social impact, individual and team, lifelong learning, and so on.

4. Effectiveness of Teaching Reform

Applying the method above teaching research and reform measures, the following pedagogical reform results were obtained as follows.

(1) Integration of knowledge and practice is realized on the basis of school professional knowledge, students master the basic principles of production organization and management in mechanical manufacturing enterprises. In the mechanical productive practice course for outstanding engineers training, they are also familiar with the general process of production management and can consider various constraints in the production process.

(2) Applying practice platform design considering both internal and external, virtual-real productive practice and other practice platforms, students are more active and in-depth understanding of mechanical manufacturing. Through real and in-depth participation in practical activities, they can also master and apply the mechanical engineers' professional quality and professional norms.

(3) Through the implementation of the whole process assessment, students can comprehensively use the professional knowledge they have learned, propose solutions to practical engineering problems in the process of production practice, and effectively analyze their feasibility. After the practice course and even graduation, they understand the necessity of autonomous learning and lifelong learning.

In general, under the background of engineering certification and excellent engineering training, students further obtain the basic knowledge and skills of machining process, machine assembly, production supervision, and enterprise management in mechanical manufacturing enterprises, and lay a solid practical foundation for graduation to work.

5. Conclusions

The modern method of engineering education involves contemporary teaching and learning practices using project and program-based learning, work-integrated learning, and integrative learning approaches [8]. Based on the characteristics of the mechanical production practice course, this paper proposes teaching research and reform oriented to the training of excellent engineers. On the basis of the production practice of typical manufacturing enterprises, the practice content is optimized through in-depth school-enterprise cooperation of Integration of professional theory and practice, multi-directional production practice of the campus platform and virtual simulation, course process improvement for outstanding engineers training. Through the reform of the new practice mode and the assessment method, the practical teaching effect is improved, the combination of more professional course knowledge and production practice is promoted, and the proposal improvement and innovation ability for actual production are cultivated so that students can better master the professional courses.

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