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THE INTEGRATIVE ANALYSIS OF OET AND EEA BASED ON THE COUPLING THEORY - WITH AN EXAMPLE OF MECHANICAL ENGINEERING DISCIPLINE

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ABSTRACT: *This paper focuses on the exploration of the relationship between the outstanding engineers training plan (OET) and the engineering education accreditation (EEA) based on the coupling theory. The necessity for the integration of the OET and EEA programs into the curriculum is analyzed. The mechanical design, manufacturing and automation discipline is taken as an example to illustrate the coupling point of the curriculum and procedures. A talent cultivation mode for the engineering application based on the coupling theory is then proposed. It is beneficial to the improvement of the students' engineering ability.*

KEYWORDS: Outstanding Engineers Training Plan, Engineering Education Accreditation, Mechanical Engineering, Coupling Theory

INTRODUCTION

Engineering plays a critical role in Chinese higher education and even in the whole world. The establishment of engineering programs and corresponding engineering education provides an important intellectual and talent support for the advancement of Chinese industries. According to related statistics, about 1047 universities have an engineering college in which there are about 15732 engineering majors and 5.584 million engineering students enrolled. In fact, the number of enrolled engineering students accounts for 32.4% of the total enrolled student population and ranks first among all majors with respect to the number of students enrolled. Moreover, 12.1% of engineering majors can be classified as mechanical engineering, which is the third largest group. Notably, the government work report of 2015 pointed out that 22 of the 29 industries (about 76%) named by Premier Li Keqiang need enormous talent supports from engineering programs. Especially at the new stage where the demands from "Made in China 2025" and "Internet Plus", the innovation and entrepreneurship are highly publicized and welcomed. Engineering programs and engineering education must be vigorously developed to meet the urgent needs for the expansion of the manufacturing industry. However, the development of engineering education in China evidently falls behind that of developed countries. Indeed, there are still many problems, such as being heavy on theory but light on practice and innovation and emphasizing individual academic achievement while ignoring teamwork.

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LITERATURE UNDERPINNING

The outstanding engineer training (OET) and engineering education accreditation(EEA) programs are two of the most critical reforms to be integrated into the curriculum of all disciplines in mechanical engineering in recent years (Lin Jian, 2010). In June 2010, the Chinese Ministry of Education began to implement the "Outstanding Engineer Education and Training Program". According to statistics as of the end of 2013, there were more than 200 thousand students enrolled in about 1257 pilot undergraduate majors among 208 pilot universities. The number of published papers related with OET and OET and mechanical engineering in China are given in Fig.1, respectively. It can be found that in the beginning year of OET 36 papers related OET were published. After 5 years, the related papers published in 2014 reached about 500. For the mechanical engineering discipline, the first paper was also published in 2010. The papers were increased from 2 in 2010 to 23 in 2014 which indicates a rapid increase.

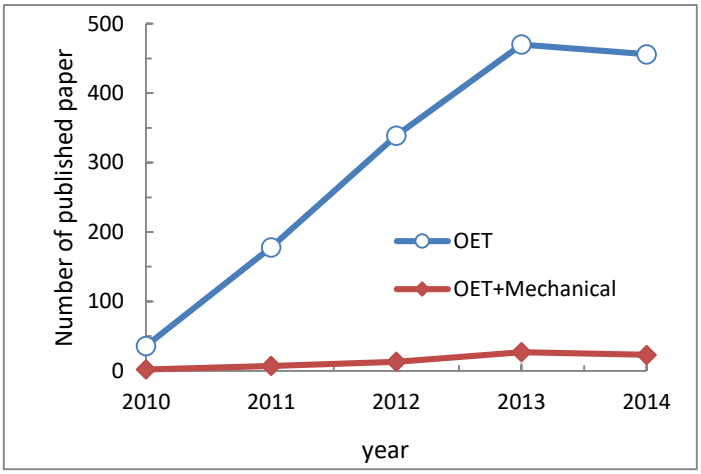

Fig.1 Number of published papers related with OET and OET+Mechanical

In the meantime, the EEA program has successfully been carried out in many other countries around the world, proving its effects in promoting the development of engineering education to a large extent, and as a result the importance of the EEA has become well-known among a wide range of engineering industries and universities (Wu Aihua, 2008; Zhang Wenxue, 2008). Fig.2 is the number of published papers related with EEA and EEA and mechanical engineering in China. It seems that the research related with EEA include two periods. The first period is 2004-2012 with the published papers increased from 3 to 34. The second period is started from 2012. 96 papers have been published till 2015. The research related with EEA in the mechanical engineering discipline was started in 2008. Then, after 4 years only 3 papers were published in 2014. It denotes that the researches of EEA in the mechanical engineering discipline are quite few. However, by the end of 2015, a total of 63 mechanical engineering disciplines in about 44

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colleges and universities in China have passed the EEA accreditation (Fig.3).

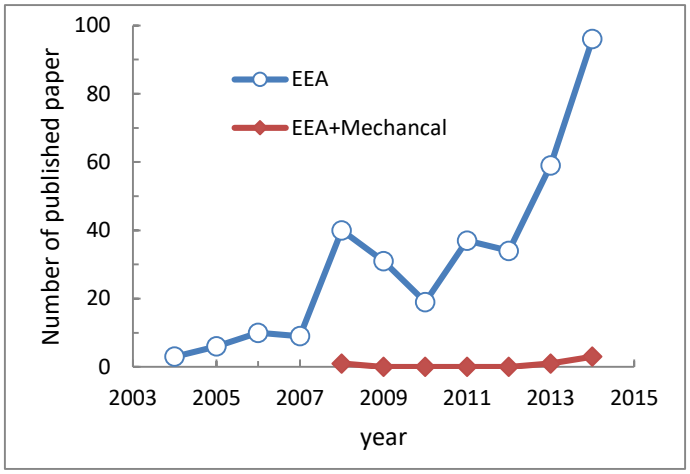

Fig.2 Number of published papers related with EEA and EEA+Mechanical

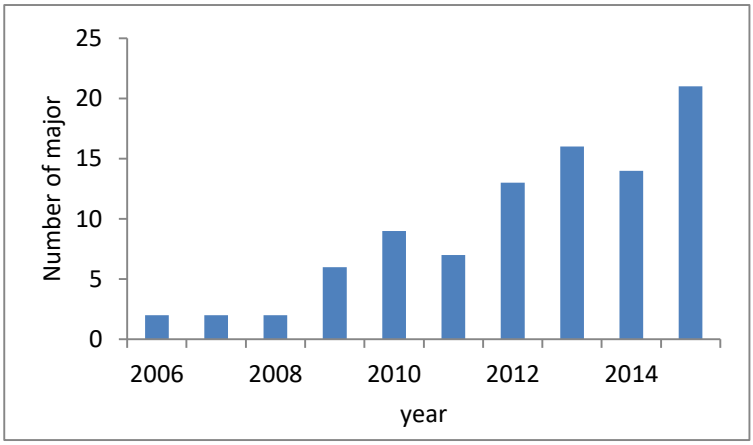

Fig.3 Number of majors passed the EEA accreditation in China

The EEA can encompass all students in the engineering school and it requires everyone to be accredited. On the other hand, the implementation of the OET program shows that most colleges and universities open 1-2 pilot majors selected from all mechanical engineering disciplines. Many universities around the country have been conducting research on parallel implementation of OET and EEA into their programs (Zhang Zhijun, 2010; Wang Yong, 2010; Lin Jian, 2013). Accordingly, this paper focuses on studying the feasibility of integrating both programs, especially after the Chinese Ministry of Education put forward reforms to transform universities and students into an application-oriented system. Therefore, the necessity and execution of this study are even more urgent today.

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METHODOLOGY

The term coupling theory is derived from physics and refers to the phenomenon whereby two or more sub-systems or motions interact with and influence each other. In general, if there is an interaction between two things, the relationship is a coupling phenomenon which often occurs in electrical engineering.

Depending on the degree of coupling, there are various forms of coupling, including common coupling, external coupling, control coupling, stamp coupling, data coupling, non-direct coupling, content coupling, etc. Coupling is an important factor affecting the complexity of a software and the quality of a design. The degree of coupling between objects in software engineering is the degree of dependency between them. Coupling is a measure of the interrelationship between the modules in a program, which depends on the complexity of the interface between the modules, the way the module is called, and the information passing through the interface. The coupling strength is determined by the following factors: (1) a module calls another module; (2) the amount of data communicated between two modules; (3) how much control of a module is applied to another module; (4) the complexity of the interface between modules. Coupling is a term commonly used in communication engineering, software engineering, mechanical engineering, where the specific meaning might be different. The specific application of the coupling theory will be separately analyzed in various disciplines.

The coupling theory is widely used in most of the disciplines in mechanical engineering to solve various numerical simulation problems and engineering problems, such as high-speed cutting simulation based on thermo-mechanical coupling, thermo-dynamic coupling analysis of structural problems based on finite element method, fluid-solid coupling analysis in the pipeline and organic multi-physics coupling analysis.

RESULTS AND DISCUSSION

Necessity for the integration of the OET and EEA programs into the curriculum

The Expert Working Group of the OET program pointed out that this program and the EEA program are inherently similar, albeit the implementation goals and standards are different. Analysis results show common points between the two programs, including that both emphasize training engineers and the importance of the standard. The differences include that the EEA program is for external evaluation, whereas the OET program is for internal reform; the EEA program encompasses all students, whereas the OET program is only applied to pilot students; the EEA program focuses on the results and certification, whereas the OET program focuses on the procedure and standards. Nevertheless, both programs complement each other. The EEA program can be used to check the progress of the OET programs, while the requirements for the OET program provide evidence for the EEA program.

Accordingly, we propose that the research on innovative ways to integrate both the OET program and EEA program will be one of the ways to reform all the disciplines in mechanical

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engineering. Some scholars have explored the practicability of the research topic in recent years. For example, Jian Lin (Lin Jian, 2013) analyzed the relationship between the quality requirements of the OET and EEA programs. They proposed to perform the quality evaluation of the OET program based on the EEA. Yang Guang et al. (Yang Guang, 2014) conducted research on the accreditation of material forming and controlling engineering based on the OET program. Shiwei Jin, et al. (Jin Shiwei, 2015) reformed the curriculum of the thermodynamics course based on the chemical engineering accreditation and OET. Caiping Song et al. (Song Caiping, 2013) reported good results on the application of OET in business majors from the perspective of international accreditation standards.

The integrative analysis of OET and EEA based on the coupling theory

Currently, all colleges and universities have adopted an independent student training program following the implementation of the OET and EEA programs. However, the above comparison between the two programs shows that both programs focus on training students to solve engineering problems and both programs interact with and influence each other in practice. Therefore, the coupling point can be found from the training program and curriculum. A coupling of the corresponding concept and standard requirements of the EEA and OET programs can be applied to the development of both programs' training plan and curriculum for pilot classes. Then, a talent cultivation mode for the engineering application based on the coupling theory is proposed with the schematic illustration shown in Fig.4. The curriculum for the engineering ability and platform for scientific innovation and engineering practice are both needed in order to couple the OET and EEA.

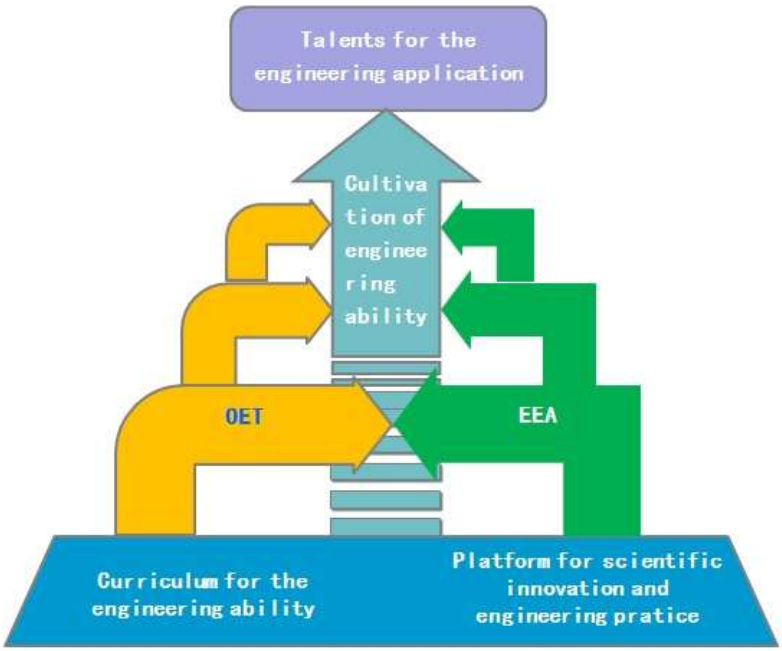

Fig.4 Schematic illustration of the talent cultivation mode for the engineering application based on the coupling theory

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The coupling can be accomplished by adding certain courses to the curriculum. The discipline of mechanical design, manufacturing and automation from the Qilu University of Technology is taken as an example. The general undergraduate education program and the OET plan for engineering accreditation, as well as the coupling of the specific curriculum, are shown in Table 1. There are eight modules: general education required courses, general education elective courses, the mechanical engineering required fundamental courses, mechanical engineering elective fundamental courses, discipline core courses, discipline specialization courses, discipline elective course, and internship, projects and thesis. Except for the two modules for general education, the others have a corresponding coupling point. For example, material mechanics is the required course for the OET plan, which provides basics and theories for understanding materials, while an addition of the industrial production analysis course to provide students with necessary knowledge and preparation for internships, projects and thesis. At the same time, this can also be applied to the EEA program with continuous improvement. For both programs, engineering basic courses (theoretical mechanics, material mechanics, electrical technology, electrical engineering, etc.) and program basic courses (mechanical design principles and methods, mechanical engineering principles and technology, measurement techniques of mechanical engineering, etc.) are added to meet the requirements of the EEA plan. In the process of implementation, the undergraduate training program for EEA is used for the discipline of mechanical design, manufacturing and automation, while the undergraduate training program of the OET program is used for the pilot classes. Through the coupling of the two training programs, the mechanical design, manufacturing and automation engineering contribute to provide a curriculum with the integration of standards and concepts from both the EEA and OET plans for students.

Table 1 The mechanical design, manufacturing, and automation curriculum

Course module	Undergraduate curriculum oriented to EEA program	Undergraduate curriculum for the OET plan	Coupling analysis
General education required course	Basic principles of Marxism, Introduction to Maoism and Theoretical System of Socialism with Chinese Characteristics, Ideological and Moral Education & Elements of Law, Situation and Policy Education(1-4), English, The Fundamentals of Computer, fundamentals of programming, career planning, Introduction to the development of science and technology and professional disciplines	Basic principles of Marxism, Introduction to Maoism and Theoretical System of Socialism with Chinese Characteristics, Ideological and Moral Education & Elements of Law, Situation and Policy Education(1-4), English, The Fundamentals of computer, fundamentals of programming, career planning, Introduction to the development of science and technology and professional disciplines	/

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General education elective course	Elective courses in different disciplines for general education	Elective courses in different disciplines for general education	
Program required fundamental courses	Advanced mathematics, linear algebra, physics, engineering chemistry, mechanical drawing	Advanced Mathematics, linear algebra, physics, engineering chemistry, mechanical drawing	Engineering chemistry is added to the curriculum of both the OET and EEA program according to the requirement of engineering accreditation. While the total credits of natural science should be not less than 15%.
Program elective fundamental courses	Electrical engineering and electrical technology, Electrical engineering and electrical technology experiment, probability and statistics I, engineering material, principle and application of microcomputer, material mechanics, Mechanical innovation design and manufacture, introduction of light industry machinery	Electrical engineering and electrical technology, Electrical engineering and electrical technology experiment, engineering material, probability and statistics I, principle and application of microcomputer, Mechanical innovation design and manufacture, introduction of light industry machinery	For example, material mechanics is the required course for the OET plan which provides basics and theories for understanding materials, while an addition of the industrial production analysis course to provide students with necessary knowledge and preparation for internships, projects and thesis. At the same time, this can also be applied to the EEA program with continuous improvement. For both programs, engineering basic courses (theoretical mechanics, material mechanics, electrical technology, electrical engineering, etc.) and program basic courses (mechanical design
Discipline field core courses	Theoretical mechanics, Mechanical principles, mechanical design, fundamentals of mechanical manufacturing technology	Theoretical mechanics, Mechanical principles, Mechanical design, Material mechanics	

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				principles and methods, mechanical engineering principles and technology, measurement techniques of mechanical engineering, etc.) are added to meet the requirements of the EEA plan.
discipline field specialization courses	manufacturing	Metal-cutting principles and tools, Numerical control processing technology, Measurement techniques of mechanical engineering, Fundament of interchangeability and measurement, hydraulic and pneumatic transmission	Manufacturing technology, Numerical control processing technology, Measurement Techniques of Mechanical Engineering, Industry production case analysis(1), Mechanical innovation design and manufacturing(2.5), hydraulic and pneumatic, transmission, mechatronic system design	
	Mechatronic Engineering	Mechatronic system design, Electromechanical transmission and control, Mechanical engineering measurement technology, Interchangeability and measurement technology, Hydraulic and Pneumatic Transmission		

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Discipline field elective course	Nontraditional machining technology, Specialty English, PLC principle and application, mechanical CAD/CAM, fluid mechanics, numerical analysis, industrial robot technology, food and packaging machinery, Light industry equipment and technology, 3D printing technology, mechanical engineering innovation and trend	Nontraditional machining technology, mechanical optimization design, mechanical CAD/CAM, fluid mechanics, numerical analysis, industrial robot technology, food and packaging machinery, Light industry equipment and technology, 3D printing technology,	Several courses in the OET program including nontraditional machining technology, mechanical optimization design, food and packaging machinery, and 3D printing will be taught by both college and companies to improve students' engineering application ability. At the same time, this can also be applied to the EEA program with continuous improvement. Mechanical optimization design and numerical analysis help student to solve real complex engineering problems which is a required ability in engineering accreditation.
Internship, projects and thesis	Engineering training, course project, manufacturing internship, engineering quality training, graduation internship (four weeks), graduation project/thesis	Engineering training, course project, manufacturing internship, engineering quality training, clerkship, graduation internship (four weeks), graduation project/thesis	The clerkship course is added to the fourth semester in the OET program to help students understand the industrial manufacturing when they start the discipline courses and improve application ability. The graduation internship is arranged for six weeks at the end of the seventh semester before the graduation design so that students can finish their graduation design in a factory/company. At

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			the same time, this can be also applied to the EEA program with continuous improvement. Engineering quality training is provided in both programs to improve students' application ability. Course design and graduation design train students gaining design experience and ability to solve problem especially complex engineering problems.

In summary, the coupling theory provides a solid theoretical basis for the integration of the OET and EEA programs. The integrative analysis based on the coupling theory also confirmed the requirements of the expert working group from the OET program. It is beneficial to the integration of the two programs and improvement of the educational system focusing on training students' engineering ability.

CONCLUSIONS

This paper focuses on the analysis of the outstanding engineers training and engineering education accreditation programs and found the coupling point of the curriculum of mechanical design, manufacturing and automation based on the coupling theory. The relationships between the two systems are also explained. In addition, a talent cultivation mode for the engineering application with the coupling of the OET and EEA plans has been established. The future research will be focused on the implementation and improvement of the proposed talent cultivation mode for the engineering application. It is expected that more and more college students will benefit from the teaching reform with the enhanced engineering ability.

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