The Framework and Methods of Quantitative Assessment for Education Reform in Industrial Engineering

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Abstract. Industrial engineering (IE) is a system optimization technology, which is also an engineering discipline involving improvement and innovation. This paper presents the discipline development of industrial engineering in China and worldwide, as well as the key points and difficulties in the reform of industrial engineering education. A framework of quantitative assessment is then proposed for industrial engineering education reform. The multi-stage task evaluation method and importance analysis theory are introduced into educational quality management of industrial engineering for the first time. It can evaluate the whole teaching activities such as teaching, competition and practice. The author expects to give ideas of effective solutions ways to achieve successful reform for industrial engineering. It may also provide reference framework and methods to support the education reform of other related majors.

Keywords: Education reform · Framework · Industrial engineering · Innovation · Quantitative assessment

1 Introduction

Industrial engineering is a system optimization technology, which is also an engineering discipline involving planning, design, evaluation, improvement and innovation of personnel, material, equipment, information, energy and other factors [1]. Industrial engineering applies natural science, mathematics, social science, especially the theory and method of engineering technology to provide strong technical supports for the production, management, and service systems with low cost, high efficiency and high benefit [2]. As an emerging profession, industrial engineering has high recognition and high employment rate in the enterprise and society. So, the IE education plays an important role in the society and technology developments.

Nowadays, there are mainly the following problems in the education reforms. First, the existing professional reform focuses on the cultivation of technology and management capacity, but it lacks of paying attention to the characteristics of industrial engineering. Therefore, it is urgent to study the innovation training system depending on the perspective of innovation ability [3]. Next, the comprehensive reform of industrial engineering in colleges and universities has achieved initial results, but it has...
not yet formed a benign operation mechanism for the sustainable development. Last but not least, in the existing evaluation, the qualitative evaluation is more than quantitative evaluation, the effectiveness of industrial engineering reforms cannot be evaluated effectively for short of quantitative evaluation index system [4].

2 IE Education Worldwide

2.1 IE Education in America

After nearly a century of development, the industrial engineering education in American universities has been very mature. It has formed a large number of distinctive industrial engineering professions in America [5]. There is full-blown training plan, clear professional direction, and perfect curriculum system. Furthermore, there are high quality handouts and teaching material. The curriculum, personnel training and scientific research in American universities are coincided with regional industrial characteristics, and combine production, teaching and scientific research in close cooperation. By entrusting enterprises scientific research to colleges and universities, it provides practice base. Both sides cooperate on education closely while the goal of cultivating talents is fully embodied in the whole process of cooperative education. The two parties build engineering research center, application development research center together and send researchers work together in the meantime.

2.2 IE Education in Europe

Recently, German Production Engineering Research Association proposes a new curriculum structure, aiming to make industrial engineering education more attractive to students. The content of the courses is closer to the industrial demands [6]. Industrial engineering students need to learn basic courses in the first two semesters before they choose a professional direction in their third semester. This will help students to understand the whole subject, also to make the students develop continuously towards the direction of engineering science [7]. Students can get practice experience which related to the teaching content by completing project in groups, at the same time, students can also improve their social competence [8]. In order to meet the long-term needs of excellent personnel in engineering, there are some main approaches. Firstly, all engineering students are required to study basic courses in the first two semesters. Secondly, introduce technology courses and recombine the curriculum related to natural science [9]. In particular, the introduction of technology courses and the reorganization of the curriculum associated with natural science will be able to meet the needs of today’s engineering field [10].

2.3 IE Education in Japan

In Japan, there are nearly a hundred of universities that have established industrial engineering courses, such as Waseda University and Tokyo Institute of Technology. Those first-class universities all have the department of industrial engineering where
the cultivating talents are mainly engaged in the line operation and management in enterprises. The engineering education in Japan advocates the concepts that arranging a variety of technical objects in reality from the scientific level, and developing technical system’s cross-correlation technique further. The industrial engineering educations in Japan aims at those talented people who have scientific attitude, engineering background, pioneering and innovative spirit, and ability of identify and solve problems by their professional knowledge. The course system which combines graduation project with practical work emphasizes experiment and practice. Therefore, it makes students master skills more practically, identify and solve problems much faster in the future.

2.4 IE Education in China

At present, there are more than 160 colleges and universities that have set up industrial engineering profession in Mainland. The colleges divide the industrial engineering profession into two categories, engineering category and management category. There are two extremes about the arrangement of industrial engineering courses. One extreme is the overweight proportion of the engineering course, on the other side is the overweight proportion of management course. In addition, comparing with foreign countries, our domestic demand for foundations of mathematics is relatively weak [11].

Hong Kong’s industry is dominated by high technology in the twenty-first century, and highly trained industrial engineers become an important resource in the industrial world. Hong Kong has a high degree of international integration, where a majority of teachers has abroad experience at American universities.

As an applied discipline in Taiwan, industrial engineering applications have transcended manufacturing into services, the government and other public organizations. The University in Taiwan set up its first industrial engineering family in 1963. It has considerable influence in the international arena after the 40-year development. Tsinghua University Taiwan Hsinchu and Yuan Ze University are in the high reputation of industrial engineering education. Furthermore, Taiwan’s electronic manufacturing is the mainstream industry, so the enterprises in Taiwan attach great importance to industrial engineering’s application in production, education and scientific research, such as Foxconn.

2.5 IE Education in Northwestern Polytechnical University

Department of industrial engineering in Northwestern Polytechnical University (NPU) originates from mechanical engineering. At the beginning, the training project, construction of course system and other aspects all followed mechanical engineering specialty, so it gets more mechanical engineering features. In addition, the research of industrial engineering in NPU started from the information of manufacturing industry, so the initial research focused on the application of enterprise management. At present, the industrial engineering in NPU is transforming to the application base and the theoretical foundation.

NPU aims to cultivate the leading talents, who can plan, design, optimize, analyze industrial systems, and can cater to wide aperture area, too. However, many things need carrying out to cultivate industrial engineering students, who have international vision
and innovative ability, such as comprehensive reform in training programs, curriculum systems, series of teaching materials, subject competitions, international cooperation and other aspects. This will play an exemplary role in the province’s industrial engineering professional development and comprehensive reform, a leading role and radiation effect, too.

3 Framework of Quantitative Assessment for IE Education Reform

3.1 Main Contents

The cultivation of comprehensive innovation ability is the biggest characteristic of personnel training in industrial engineering. Based on the philosophy of system theory, this paper uses the method of quality function deployment (QFD) to support the cultivation of comprehensive innovation ability, considering stages from the top design (training program, curriculum system) to the specific implementation (teaching model, comprehensive experiment, subject competition, business practice), and makes the innovation ability training throughout the training program, curriculum system, classroom teaching, business practice, discipline competitions and other teaching links [12].

The essence of industrial engineering is that there is always a better way. The reform in this paper need to absorb essence, draw on the method of Plan-Do-Check-Act (PDAC) and the experience of the theory of importance analysis which comes from the theory of quality and reliability, identify the weak links in the comprehensive reform, and clear the key factors that affect the quality of professional education, guide the improvement and optimization of the culture system with it, optimize and improve the teaching quality with a definite object, construct continuous improvement.

The core tool of modern industrial engineering is quantitative analysis. On the basis of long-term scientific practice and research on quality management science, use the multi-stage task reliability assessment method, and divide the professional assessment into two stages: still at college and already graduated. Start with the feedback from students, teachers, administration, enterprise, graduate tutors and so on, and research on analytic hierarchy process (AHP) basing on quantitative and semi-quantitative evaluation data, then lay the foundation for the continuous optimization of training programs, curriculum system and personnel training [13].

This paper takes the undergraduate education of industrial engineering specialty in Northwestern Polytechnical University as the demonstration object of the application, and the results facilities to form colorful innovative educational activities. These activities include course content covering innovative approach, teaching mode of creating innovative thinking, subject competitions that helps to train the creative consciousness and enterprise practice that helps to exercise innovation ability. That will guide students to study basing on problems, projects and interests, and gets continuous improvement and quantitative assessment at the same time. Moreover, take Shaanxi Institute of Mechanical Engineering industrial engineering and management as
communication platform, and introduce the reform process and advantages of industrial engineering specialty to colleges and universities in Shaanxi Province.

3.2 Main Objective

In order to carry out an impeccable industrial engineering education reform, the placement of industrial engineering graduates is of great significance to this paper. By analyzing the relevant literature, we can learn that industrial engineering undergraduate students have three choices. First, to engage in work related to industrial engineering; second, continue the industrial engineering learning, study in the graduate school for a master’s degree; third, become a civil servant in government departments. Therefore, the employers of industrial engineering students in the future are mainly enterprises, graduate schools and government departments. The future development of industrial engineering students is described by fishbone diagram as shown in Fig. 1.

![Fig. 1. The future development direction of industrial engineering graduates](image)

According to the future development direction of industrial engineering students, we believe that industrial engineering students’ qualified capability constitution is complex, as shown in Fig. 2. Industrial engineering education reform will help students to get the complicated capability constitution.

Based on the existing comprehensive reform results of industrial engineering, this paper analyzes the comprehensive reform of industrial engineering specialty in universities of developed countries, Hong Kong and Taiwan, and studies the training system of industrial engineering innovation ability, the continuous improvement of industrial engineering and the method of quantitative assessment, improves and perfects the mode of cultivating innovative talents and constructs a new system of healthy development of industrial engineering. Verifies the effectiveness of the new system through the demonstration of industrial engineering in Northwestern Polytechnical University, the promotion and application of colleges and universities in Shaanxi Province, ultimately provides effective solutions and ways to achieve the industrial engineering comprehensive reform, and also provides reference ideas and reference framework for other professional sustainable and healthy development.
There is several teaching problems need solving here. First of all, when establishing the new system of cultivating innovative talents in industrial engineering, which has the main theme to train innovating talents, top level planning and system construction are lacking in the process [14]. Second, when establishing the benign operation mechanism of sustainable development of industrial engineering, which is based on the importance analysis theory and PDCA method in quality and reliability management, scientific guidance methods are lacking in the continuous problem solving process. Third, when establishing the quantitative evaluation index system, which is based on the quantitative evaluation method in system engineering, the problem is how to evaluate the efficiency of industrial engineering reform accurately. Finally, how to colligate industrial engineering reform model, how to abstract the scientific reform and development of new ideas and new models, how to form a set of overall solutions for other professional sustainable and healthy development, how to provide reference ideas and reference framework, the above problems need to be researched deeply.

4 Methods of Quantitative Assessment for IE Education Reform

4.1 Main Methods

This paper intends to in-depth analyze the industrial engineering professional comprehensive reform experience and effectiveness in domestic and foreign universities by using the method of investigation and analysis. According to the characteristics and existing problems of industrial engineering in colleges and universities in Shaanxi Province, the paper sorts out the problems in the comprehensive reform of industrial engineering. Focusing on the cultivation of innovation ability, the continuous improvement of education and the evaluation of effectiveness, locate the problems in the project research accurately.
Combine the quality of talents capacity and the quality function of the educational process, circumfusing the whole process of cultivating innovative talents in industrial engineering, basing on the QFD method. Establish a matrix to analysis the relationship between talent quality demand and cultivating project. Develop the quality of the function step by step, focusing on the education process of the quality of talent. Plan and make improvement systematically. Exchange the need of social and employing unit into the requirement of talents’ quality and ability, furthermore, transform it into the corresponding countermeasures that should be taken. Then, through expanding and deriving into the various teaching processes, a scientific and systematic top-level planning and overall deployment can be formed at last.

Figure 3 shows that the QFD method can identify the needs of the stakeholders, and the AHP method introduces competitive advantages and determines the weight of competitive advantages. Then use the AHP calculation results as part of the QFD input, use the QFD method to select and determine the core attributes of the competitive advantages. Ultimately, the training program can be designed and evaluated based on the integration of QFD and AHP.

![Fig. 3. Design training program based on AHP and QFD integration](image)

Analyze the comprehensive reform and educational quality of industrial engineering, basing on the theory of importance analysis in reliability management, in accordance with the quintessence of industrial engineering and the law of learning. And then identify the weak links in the reform of industrial engineering. Next, make the core factors that influence the improvement of professional education quality clear. At last, develop improvement and optimization of core training process and links.

Carry out industrial engineering professional comprehensive persistent reform, following the PDCA scientific quality management procedures, basing on the PDCA continuous improvement model. Form the personnel training closed-loop management according to multi-source, multi-channel information feedback, including the needs of the community, the employing unit, senior instructors, students and the results of the assessment.

This paper uses the PDCA model to analyze the optimization of industrial engineering education. PDCA as a mature model has the characteristics of continuous
optimization and continuous improvement. By modeling the product or event, the model is analyzed in four steps to achieve the purpose of optimization and improvement. PDCA cycle is currently more used in quality management, health care, manufacturing and other fields. The core idea of the PDCA cycle is similar to the core idea of industrial engineering, emphasizing optimization and improvement. The importance analysis is a scientific method of calculating the importance of each component in the system and the weakness of the identification system. Through the importance analysis, the importance ranking of the system components is obtained, and then the PDCA cycle is used to analyze and find the places that need to be optimized to achieve the continuous improvement of the industrial engineering education.

Summarize the evaluation index that reflects the comprehensive reform of industrial engineering, on the basis of long-term scientific practice and research on education quality management. Establish quantitative evaluation methods to evaluate the whole teaching activities such as teaching, competition and practice, based on AHP and multi-stage task evaluation methods. And finally establish a quantitative evaluation system that runs through the trinity of knowledge learning, innovation ability training and quality training process [15].

Form colorful innovative educational activities, including the course contents covering innovative approach, teaching modes of creating innovative thinking, subject competitions training the creative consciousness and enterprise practice exercising innovation ability, those above should be finished by using empirical methods, which are combined with the Northwestern Polytechnic University of industrial engineering innovation talent training process, and guide students to study, based on problems, projects and interest. Concern about the development of ability, quality, innovation and sense of responsibility, inspire thinking, broaden horizons, tap the potential, protect students’ critical spirit and beneficial personality to verify, and improve the research results.

4.2 Main Advantages

The multi-stage task evaluation method and importance analysis theory in industrial engineering field are introduced into educational quality management field for the first time, carry out the improvement plan of industrial engineering professional education quality and continuous improvement, and find the way of theoretical exploration on the improvement of educational quality.

We build a trinity of personnel training model about quality goal orientation, application of process method and innovation ability training, following the process approach principle of personnel training. And we form a continuous improvement model of PDCA comprehensive education quality in industrial engineering specialty, which has a purport to improve the educational quality continuously.

This paper carries out the comprehensive reform and continuous optimization of industrial engineering, based on the continuous improvement of the closed-loop model and quantitative assessment, which is a beneficial exploration for the current professional reform, enriches the means of education and teaching reforms.
5 Conclusion

Based on the philosophy of system theory, this paper analyzes the education reform of industrial engineering in China and worldwide, considering stages from the top design to the specific implementation. The methods and innovative ability training system which supports the cultivation of comprehensive innovation ability are also studied with the method of quality function deployment. Then, this paper proposes a framework for the quantitative assessment method of industrial engineering education reform. It introduces the multi-stage task evaluation method and importance analysis theory into educational quality management. The continuous improvement model of industrial engineering education will help improve the educational quality.

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References