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Curriculum System Optimization Based on Integration of Enterprises and Universities Using QFD Under the Background of Engineering Education Professional Certification

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ABSTRACT Taking the certification of engineering education as an opportunity, the internal relationship between industry and education is explored. Starting from the construction of the curriculum system, the quality function deployment (QFD) method is applied to the optimization of the curriculum system oriented to the industrial demand. Based on the evaluation of the importance and achievement of graduates' core competence by alumni graduated more than 3 years and employers, using Likert five-level scale combined with the right wall of the house of quality to quantify the weight of graduation core competence, this paper reveal the correlation between the graduation core competence and the construction of curriculum system module through incidence matrix and transfer the graduate core competencies into improvement demand degree of the course modules. This paper takes the curriculum system construction of the major of Mechanical Design, Manufacturing and Automation in Guangdong Ocean University as an example to carry out the research.

1. INTRODUCTION

The transformation of the international order is accelerating. Manufacturing is the foundation of a country and the base of a strong country. It is an important symbol of a country's comprehensive strength and international competitiveness. China promotes the implementation of the manufacturing power strategy with the national strategy plan of Made in China 2025 as programme of action for the first decade. At present, the manufacturing industry is facing the opportunities and challenges of a new round of scientific revolution characterized by digitalization, networking and intelligentization. Being guided by the demands of advanced manufacturing industry development and training engineering talents who will keep pace with The Times are the important support for China to implement the manufacturing power strategy. The transformation and upgrading of China's manufacturing industry, intelligence in production and its changes in production methods require engineering talents to have a compound knowledge structure of design, production, management and decision-making, the ability to creatively solve complex engineering practical problems and the ability of lifelong learning. However, the disconnection between the training of manufacturing talents and the actual needs of the industry, and the lack of integration of industry and education have become a prominent problem restricting the transformation and upgrading of China's manufacturing industry. It is urgent to explore the talent training mode driven by national strategy and industrial development. Mechanical Manufacturing and Automation Specialty, training compound senior engineering and technical personnel who engaged in mechanical engineering and related fields of technical research and development and services, product design and manufacturing, production operation and management, and other aspects of the work, is the mainstay of manufacturing power. Mechanical Manufacturing and Automation Specialty should

take the lead to achieve the coordinated development with the industry. Curriculum is the basis of education. Combining industrial development trends, changes and skill requirements, exploring the internal correlation among industrial demand and curriculum construction, and scientifically setting and optimizing the curriculum system are the important links to realize the integration of industry and education [1].

This paper takes Mechanical Design, Manufacturing and Automation major of Guangdong Ocean University as an example, takes the engineering education professional certification as an opportunity, takes the key link course construction in the talent training chain as the starting point to construct the curriculum system oriented to core competence cultivation. The Quality Function Deployment (QFD) method is adopted to transform the importance and satisfaction of the industry to the core competence of the training target into the quantitative evaluation of the improvement demand of the curriculum system module, so as to guide the scientific decision-making of optimizing the curriculum system. This research method can effectively map the industrial demand to the optimization of the curriculum system and solve the engineering education problem that the construction of the curriculum system lags behind the industrial technological change.

2. The Questionnaire Design of Core Competency Evaluation Oriented to Industrial Demand

Ability-oriented education model, which focuses on cultivating core competencies, has been widely applied in European and American industries and education circles [2-3].This model is highly compatible with the course system in IEET certification to ensure the major continues to achieve the core competencies required for graduates. IEET certification requires that all specific courses and schedules should be developed around existing educational objectives and core competencies that highlight the process and effectiveness of continuous improvement. Under the concept of results-oriented education, this paper adopts Likert five-level scale to design a questionnaire to quantify the importance and satisfaction of the industry to the core competence of talent training program. The designed table is shown in table 1 and table 2. Alumni with more than 3 years of graduation and employer were taken as the research objects to represent the industrial demand. Individual interview and focus group interview were conducted. Conduct surveys twice every three years for regular evaluation, reflection and continuous improvement. The importance evaluation in Table 1 indicates the importance of this ability in the minds of graduates or employers, and reflects the expectations of graduates or employers on core competence. The degree of achievement evaluation in Table 2 is to evaluate the satisfaction of core competence, and to judge whether the effect of core competence cultivation is satisfactory.

Table 1 Questionnaire for Evaluation of Importance of Core Competence

Importance / Core Competence	5 Very Important	4 Important	3 Normal	2 Not Important	1 Very Unimportant
Core Competence					

Table 2 Questionnaire for Evaluation of Reach of Core Competence

Reach / Core Competence	5 Very Satisfied	4 Satisfied	3 Normal	2 Dissatisfied	1 Very dissatisfied
Core Competence					

3. Optimization of Curriculum System Based on QFD House of Quality

QFD [4] is to transform customer needs into quality characteristics, to ensure that the key needs of customers and the company's core technology are systematically expanded to quality characteristics

such as functional components and process variables of the product, thereby forming product quality that meets customer requirements. Based on the customer-demand-oriented source and flow management thought of QFD, this paper defines "what to do" (core competence oriented to industrial demand) and "how to do" (course system construction) key core competences can be identified and core competence of graduates can be injected into the construction of the curriculum system. The constructed QFD five-factor house of quality is shown in Figure 1.

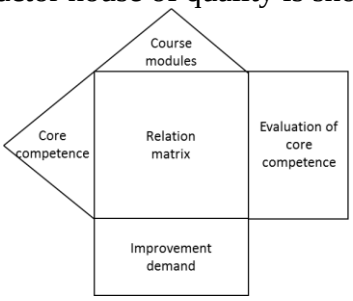

Figure 1 QFD quality house

The core competence is the professional competence of graduates set according to the industry's requirements for professional competence and the characteristics of universities.

The right part is to rank the core competencies in order of importance, as shown in the table 3.

Table 3 Evaluation of Key Core Competencies

Core Competence	Importance	Satisfaction	Satisfaction Improvement Goals		Evaluation Of Key Core Competencies	
			Satisfaction Goals	Level Improvement Rate	Absolute Weight	Weights

The importance degree and satisfaction degree are determined by the industrial questionnaire, and satisfaction goals are set based on the evaluation results of importance and satisfaction, combined with core competence goals. The improvement goal is the expression of the degree of industrial demand. For example, the importance evaluation of a certain core competence is "4", indicating that the expectation of the industry is "4" and the satisfaction is "3", indicating that the perceived quality is mediocre. To this end, an improvement target of "5" or "4" can be proposed for this core capability to ensure the fulfilment of customer expectations. After the improvement target is determined, the level improvement rate can be obtained: Level improvement rate = satisfaction target/satisfaction.

Then the absolute weight of core competence can be calculated: Absolute weight = importance × horizontal improvement rate. Then, it is converted into the weight of customer demand: Weight (Mj) = absolute weight/sum of absolute weight of each demand ×100%.

Match the course modules to the quality characteristics in the room of quality and fill in the ceiling of the room of quality, as shown in table 4.

Table 4 Course Modules

Curriculum System	Course Modules			
	Core Course of General Education	Core Courses of Professional Education	Specialized Education Courses	Professional Integrated Practice

The core of QFD is "relational matrix". Relational matrix realize the transformation from industrial needs to the construction of the curriculum system. The industry evaluates core competencies from two dimensions of importance and satisfaction, and then sorts the core competencies to determine the key core competencies. Then the relationship matrix prompts the relationship between them and the curriculum system. The core competencies are transformed into the demand for curriculum improvement which is used for curriculum system optimization.

A. relational matrix: the evaluation table of key and core competencies and the course modules are arranged vertically and horizontally and combined into a matrix to reveal the interrelationship between core competencies and course modules in the form of a binary table.

B. correlation determine: corresponding intensity correlation respectively with the symbol “⊙”, “○”, “△”, and give the corresponding weights, as shown in table 5. Correlations are determined by experts.

Table 5 Relation Matrix

Corresponding Intensity	Symbol	Assignment
Strong Relationship	⊙	3
Moderate Relationship	○	2
Weak Relationship	△	1
No Connection	Blank	0

Through the transformation of relational matrix, the course module improvement needs are clarified. On the basis of the relational matrix, transform "key core competence" to "key course module", That is, the weight of the key core competence evaluation is allocated proportionally according to the relationship strength according to the relationship matrix. Then, the scores of each requirement are vertically aggregated to determine the degree of improvement of the course module. If the value is large, optimizing the module can improve the industry's satisfaction with the core competence. The evaluation calculation formula is as follows:

$$\omega_i = \sum M_{ij} \cdot a_{ij}$$

Where M_{ij} is the importance (weight) of corresponding core competence; a_{ij} is the corresponding relational strength value.

3. Case Study

Mechanical Design, Manufacturing and Automation major of Guangdong Ocean University is dedicated to gradually cracking and perfecting the "industrial-educational integration" talent training model, and taking the engineering education professional certification as an opportunity to make use of the resource advantage of regional industrial cluster, explore the internal relationship between industry and education, so as to promote the reform of engineering education in the university. Starting from the link of curriculum construction in the talent training chain, QFD method is used to map the industry's evaluation of core competence into the curriculum construction. The core competence of the 2019 talent training program for Mechanical Design, Manufacturing and Automation major includes :(1) having good scientific and humanistic quality and certain knowledge of engineering law, and consciously observe professional ethics; (2) have the necessary basic knowledge of mathematics, natural science and machinery, as well as the professional knowledge of mechanical design, manufacturing and automation; (3) strong practical ability in mechanical design, manufacturing and automation, able to effectively analyse, research, design and develop complex engineering problems in complex mechanical engineering related fields;(4) have good teamwork spirit and communication skills in a multidisciplinary team, and have certain international vision of technology and economy and cross-border communication skills;(5) have a strong sense of innovation and ability, can adapt to the continuous development of technology, economy and society;(6) have ability to interpret public policies, and ability to organize and manage production. In order to make an evaluation of the importance and achievement of the core competence oriented to the industrial demand, the major conducts a questionnaire survey twice every three years, aiming at the alumni who have graduated from Mechanical Design, Manufacturing and Automation major for more than three years and the relevant employers who need mechanical design, manufacturing and automation professionals. Each time, 180 questionnaires are filled out (120 are alumni more than 3 years after graduation, and 60 are employers). As personal interviews and focus group interviews are adopted, 180 questionnaires are

valid. The core competency importance and achievement scores of the questionnaire were included in the core competency importance and satisfaction unit of the house of quality. The current curriculum modules of the major include: (1) general education module: including mathematics, physics, computer science, foreign language, innovation and entrepreneurship education and other public basic general education courses, to cultivate students' comprehensive qualities in natural science, humanities, foreign languages and other aspects;(2) professional education module: including specialized courses of mechanical drawing, mechanical design, material mechanics and other discipline specialized course， to train students to master professional knowledge of the subject systematically;(3) professional specialty modules: package design, manufacturing, hydraulics, offshore engineering equipment, tropical crop machinery and other direction courses, to cultivate the professional knowledge of a certain field of the major, so that students have the preliminary ability of scientific research and technical development;(4) professional comprehensive practice module: including course design, practical training, graduation design and other courses to cultivate students' engineering practice and application ability. According to the questionnaire data, graduation core competence requirements and curriculum system status of Guangdong Ocean University, the QFD quality house constructed is shown in table 6.

Table 6 QFD quality house

Curriculum system / Core competence	General education module	Professional education module	Professional characteristic module	Comprehensive Practice module	Key core competencies					
					Importance	Satisfaction	Improvement goal		Absolute value	Weight %
							Satisfaction goal	Horizontal improvement rate		
Core competence1	⊙	△	△	○	5	4	5	1.25	6.25	16.6
Core competence2	○	⊙	○	⊙	5	4	5	1.25	6.25	16.6
Core competence3	△	⊙	⊙	⊙	5	3	5	1.67	8.35	22.1
Core competence4	○	△	△	○	5	4	5	1.25	6.25	16.6
Core competence5	△	△	○	⊙	4	3	4	1.33	5.32	14.1
Core competence6	⊙	△	△	△	4	3	4	1.33	5.32	14.1
Importance	195	178	175	239						
Weight（%）	24.7	22.6	22.2	30.4						
Ranking	2	3	4	1						

According to the results of the house of quality conversion, the importance weight of comprehensive practice module is the highest among the course system module, accounting for 30%, indicating that the course system module is closely related to the core competence with high importance and strong requirements for improvement of satisfaction. This module is the key direction of course system optimization. This conclusion is also consistent with the current reality that the training of manufacturing talents is divorced from the actual needs of the industry, the integration of industry and education is not deep enough, and the practice of engineering education is weak.

4. Conclusion

With the development of deep integration of industry and education, China's engineering education is facing new opportunities and challenges. In the process of industrial transformation in the new era, the construction of a new mechanism for the integration of production and education and the realization of high-quality collaborative education have become the actual needs of engineering education. The course system optimization method based on QFD provides objective decision-making basis for the course system construction.

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