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Organizational study on multi-discipline based engineering education in China

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Abstract

There are many evidences to show that engineering education should be built on the base of multi disciplines, including technological and non-technological ones, in order to help its graduates work with cross disciplinary engineering issues in multi cultural circumstance. Therefore, if an engineering programme is supported by a number of different disciplines, the benefit to engineering education would be found not only in the integration from multi disciplinary academic resources, but also in quality and efficiency improvement. In order to facilitate the proposed multi discipline supported engineering education, a two dimensional model of academic organizations for higher engineering education is developed in this paper. Academic organizations in higher engineering education institutions are cataloged into two types which stand for real and virtual dimensions respectively in the model. All the academic organizations built based on different disciplines, such as faculties, departments, or schools are considered real organizations while all the programmes which integrate different academic resources from different disciplines are supposed to be virtual organizations. The study finds that with this model it is easy to support teaching for the new challengers of higher engineering education. Also, the study shows that the model will facilitate the quick response to the needs in society and the integration of different academic resources for teaching.

Keywords: Academic organizations; higher engineering education; multi discipline; China.

1. Introduction

The reform of higher engineering education has to be carried out according to the needs of manufacturing industries due to the fact that most of higher engineering education graduates work in manufacturing industries. The new trends of manufacturing industry development in the world are considered as worldwide competition, rapid change of markets, environment protection and technological innovation. Thanks to the modern technology of communication and transportation, many multi national companies do their business everywhere in the world and, on the other hand, a great number of small and medium-sized enterprises in each corner of the world work together for the same business opportunities by the Internet. Manufacturing systems become more complicated and worldwide than before.

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Because of the new changes in manufacturing industries, the employees, particularly the engineers in manufacturing companies are required to develop their abilities for working in the new environment of manufacturing. They have to know how to catch up the opportunities in market quickly by use of current resources either from their own companies or from the other companies, how to deal with the cultural and regional variability caused by globalization effectively in engineering project implementation, how to integrate different technologies in products development and in projects implementation, and how to keep all the engineering activities environment friendly. Furthermore, in China and other similar developing countries, higher education experienced from elite to mass higher education in past decades and there are a number of new problems encountered in engineering education. The working environment of Chinese engineers changed greatly in the past thirty years as the transformation of the country to market economy.

In this situation, traditional way of higher engineering education, in which a programme is usually supported by a single discipline, faces great challenges and modern engineers have to be trained based on multi discipline environment to develop the abilities for dealing with complicated and comprehensive engineering issues. It is very important to find a new organizational model for multi discipline supported higher engineering education.

In this paper, the relationship between programmes and disciplines is analysed and a two dimensional organizational model is developed to describe how different disciplines support the operation of programmes in higher engineering education effectively. The positive effects of the model to higher engineering education reform are shown in different aspects.

2. Problems and challenges in modern higher engineering education

Nowadays engineers have to know how to work in multi cultural environment with people from different lands and many researchers published their studies in this subject. Bidanda *et al* (2006) highlighted that the outsourcing of functions and jobs to offshore locations in manufacturing industries is now affecting engineering careers. The next generation of engineers will need to possess the ability to work seamlessly across cultures, have outstanding communication skills and be familiar with the principles of project management, logistics, and systems integration. They reached the conclusion in the countries where manufacturing industries emirate to outside. However, the conclusion is supposed valid in the countries that immigrant manufacturing industries. Kinkel and Maloca (2009) pointed out that every fourth to sixth offshoring activity is countered by a backshoring activity in the following 4-5 years in German companies. Main motives triggering off backshoring activities are shortcomings in flexibility and ability to supply in the international supply chain and quality problems at the foreign location. Their results imply the cross culture issues related to the personnel involved in manufacturing systems. Majocchi and Presutti (2009) found that foreign direct investments by multinationals are influenced greatly by the factors such as entrepreneurial culture and entrepreneurial resources in an area. There are some issues caused by the conflicts between different cultures in economic activities. Vecchi and Brennan (2009) proved the validity of the“ culture-specific” argument as an exploratory construct for innovation and illustrated the relevance of national cultures to process innovation within the context of global manufacturing.

In the era of globalization, it is more important for engineers to understand and to deal with non-technological issues than before. An engineering system is considered as an integrated one with technology, organization and personnel, and much attention has been paid in the issue. The study of Boks and Diehl (2006) shows in engineering environment sustainable development is one of key problems and it should be embedded into regular courses. Another issue that is emphasized in engineering education is engineering ethics. Shallcross and Parkinson (2006) presented three fictional scenarios that pose ethical dilemmas set against industrial chemical engineering environments for undergraduate chemical engineering curriculum. Luthje and Prugl (2006) suggested that universities should intensify their efforts to implement educational programs to foster the development of interdisciplinary work experience among students. Such courses can help reduce stereotypical perceptions and develop a more realistic view of cooperation challenges.

All these studies pointed out the fact that modern engineers are no longer limited their knowledge and abilities in their own engineering disciplines and they have to learn how to reach their solutions in real engineering environment by multi disciplinary ways. Furthermore, in China there are more other challenges to higher engineering education because of the rapid development and transformation of the country.

In the past thirty years, great changes took place in economy as well as in the environment of higher engineering education in China. In this period, the GDP (Gross Domestic Production) per person in China increased

from about 190 US Dollars in 1978 to more than 2000 US Dollars in 2008 and now China's GDP ranks the third in the world. The economy system in China has changed from so called "planning economy" to free market system. Meanwhile, the higher education in China has moved from elite education to mass education in the past ten years as the development of its economy. For example, the gross enrolment rate in China increased from 9.8% in 1998 to 24.1% in 2008. Nowadays, the labour market in China has also presented a great change and new graduates will encounter severe competition in their job hunting (Li, F., *et al*, 2009). They have to learn more than before in higher institutions.

Because of the changes from the outside world and the changes from China's economic system, the higher engineering education in China has to reform itself to help students obtain the abilities to face the challenges from globalization, from multi cultural engineering environment, and from more integrated and complicated engineering issues.

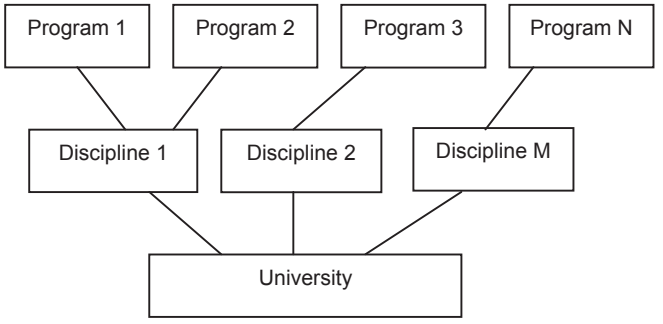

Figure 1 Organizational framework of discipline based program

However, in the past thirty years, the high engineering education in China has not come through so many changes as that in economic sector. Recently, the reform of teaching contents, lab facilities, instructing methodology, as well as the missions of education attract quite a lot of attention of researchers and educators in China. However, very little attention has been paid in the issue of organizational structure in higher engineering education. At present in China, different undergraduate programmes are usually based on and operated by different disciplines or faculties at a university. Each programme belongs to a certain discipline and most courses of a programme are delivered by the academic staff in the discipline except a small proportion of so called "common courses" like English, mathematics and so on. Fig. 1 shows the organizational structure of programmes and disciplines at many Chinese universities. In this way, it is difficult to share courses across different faculties because a programme is usually possessed by a certain faculty or school, which is normally based on a certain discipline. Academic staff in one discipline are usually not able to deliver cross discipline knowledge to engineering students. It is harmful for students to develop their abilities in multi disciplinary environment. The programme seems too "pure" in discipline and the students are not so eligible to deal with complicated and multi discipline problems in real engineering environment.

3. A two-dimensional model for multi-discipline based engineering education

One of the solutions to these problems is to re-organize the organizational structure for engineering education at universities and then to break direct links between programmes and disciplines. In fact, a programme is considered as a set of different courses and therefore, an open philosophy of higher engineering education should be introduced. Different disciplines or faculties at universities should give up their possession to programmes and all the programmes should be operated on university level. A faculty only provides its own courses to different programmes based on its own discipline. These courses are considered as the core competence of the faculty and stand for its contributions to different programmes. A new structure of academic organization at universities is suggested in this paper to facilitate this new idea of multi discipline supported higher engineering education. Fig. 2 shows the new organizational structure of multi discipline based programme in higher engineering education.

Based on the organizational structure displayed in Fig. 2, a two dimensional model can be developed to present the relationship between disciplines and programmes. In the model illustrated in Fig 3, there are two dimensions. One dimension represents all the disciplines at a university. All the academic resources, such as faculty members, laboratories, academic equipment, etc. are allocated into these disciplines, which are usually named by faculties, departments, or schools. That is to say, these disciplines are real organizations and therefore they stand for the real dimension in the model. On the other hand, all the programmes, which are groups of courses, could be considered as the other dimension of academic organizations but obviously these organizations are virtual ones because they don't have their own academic resources. All the academic resources needed to support a programme are provided by different disciplines in the form of courses. That is why this dimension is called virtual one.

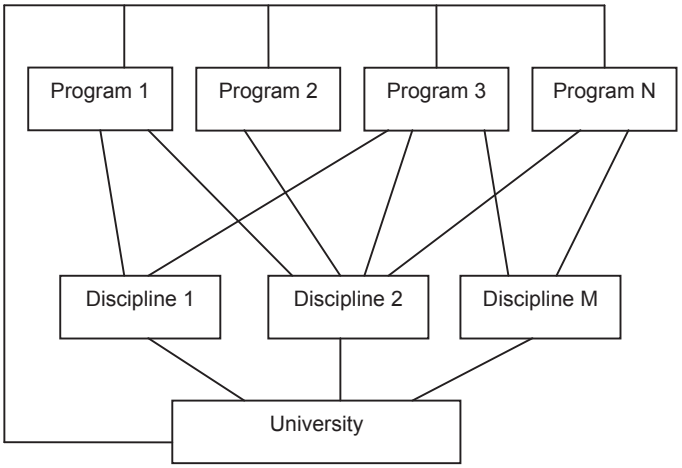

Figure 2 Organizational framework of multi discipline based program

In this two-dimensional model proposed in the paper, the academic organizations in each dimension have different characteristics. In real dimension, all the disciplines are relative stable while all the programmes, on the other hand, in the virtual dimension, could be relatively changeable because of the rapid change of needs in human resource market. In fact, a discipline is referred to as a special branch of sciences, technologies or humanities, and it takes long time to develop a new branch of areas of studying. A new human resource need in society will usually be created with a few years or even shorter. Furthermore, the other characteristic of the real dimension is the pureness of disciplines. A discipline is a special set of knowledge and a faculty is a group of academic staff working in the same discipline. That is to say, a discipline is a special area of studying and tends to be narrow in the area of research and teaching. A programme is cross disciplinary and comprehensive in higher engineering education, which developed by integrating multi discipline resources from different faculties or schools.

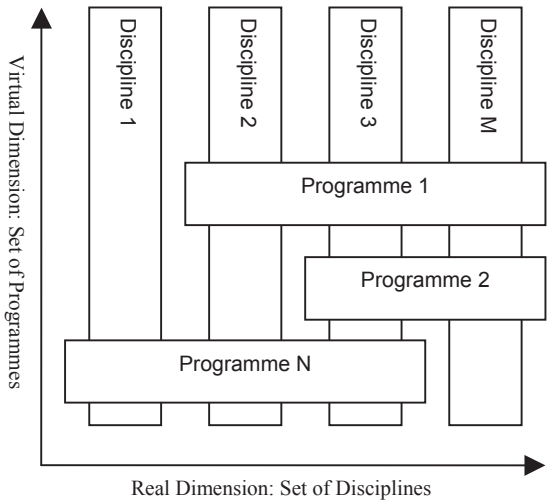

Figure 3. Two-dimensional Organizational Model

In practice, the model suggested in this paper is implemented in some cases at some extent. For example, mechatronics is a programme that can often be seen in engineering education in China. There are two ways to develop the programme. One way is to build it on the base of the programme of mechanical engineering by adding and reforming some courses. In this case, the programme is usually operated by the discipline of mechanical engineering and a lot of efforts will be paid in developing new courses, in which necessary resources such as lab facilities and lecturers have to be found. All these activities are time consuming and expensive. The other way to develop the new programme is to integrate academic resources from the discipline of mechanical engineering and the discipline of electrical engineering. In this case, the programme is jointly operated by the two disciplines that deliver courses respectively for the programme and the needs to new resources can be minimized as much as possible. Also in this case, the programme of mechatronics is considered as virtual organization, in which all the faculty members who are involved in the programme are virtual members. On the other hand, these people are real members in the two real organizations and work in these two engineering disciplines respectively.

4. Discussions and conclusions

It is obvious that with this organizational model multi discipline based engineering education will be implemented easily and effectively. Different resources from different disciplines can be integrated for an engineering programme in order to meet new challenges and rapid changes in higher engineering education. Furthermore, it is more important to conduct such a reform in academic organizations for higher engineering education in China because there are many traditional single discipline supported programmes and the graduates are

suffered in “narrow” in their knowledge and in lack in their comprehensive abilities in dealing with real engineering issues in the time of globalization and in free market economic system in China.

In addition, there are two other advantages that are discussed in following.

The first advantage of this model to engineering education is that it facilitates research-supported teaching to maintain high quality of education. With this model, a real organization, i.e. a faculty or a department only provides some of the courses for a programme, which are related to its own academic area. In this case, the teaching and research activities of academic staff can coincide as much as possible and they can focus on their teaching in their own area just as they do in their research work. While in traditional way, in which a programme is possessed by a faculty, it is quite often that faculty members are required to deliver courses out of their research areas.

The second advantage of the model is the quick response of engineering education to the changes in society. In this model, a programme is considered a virtual organization and the idea of modularization can be used to develop new programmes or to reform current ones. If there are new needs to future engineers, a new programme can be developed by integrating modulated courses from different disciplines quickly and easily at low costs. In this case, new programmes can be developed by integrating current academic resources from different real academic organizations. That means a group of faculties or schools at a university can build a dynamic alliance for a new opportunity in human resource market and then the competence of the higher education institutions can be enhanced greatly in this way.

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