A DFX and concurrent engineering model for the establishment of a new department in a university

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Abstract

The natural focus of concurrent engineering (CE) and design for X (DFX), as commonly used by manufacturing industry, is on product design or new service development. The present study applies the DFX technique in a CE environment to the planning and design of a new department in a university, and thus develops a comprehensive model for such an undertaking. The model identifies two stages in the overall process: the planning stage and the design stage. The planning stage includes four dimensions, whereas the design stage includes 11 dimensions. The dimensions are interdependent; indeed, the dimensions cannot be implemented separately and sequentially. The model must be implemented in a CE environment. A case study is then presented in which a department of leisure management at a university is established using the model described. The implications of the case study and the final conclusions of the paper are then presented.

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1. Introduction

The twenty-first century is the era of the globalized knowledge economy for a wide range of business activities, including university education. As the educational market has become liberalized, Taiwan has recently introduced reforms in educational policy. These reforms have been especially marked since the entry of Taiwan to the World Trade Organization (WTO). The rapid growth in university education has changed the nature of the Taiwanese educational sector from its original model of elite education to one of mass education and, subsequently, to a system of universal education (Ministry of Education Statistical Department, 2004). However, these changes have created imbalances between supply and demand in university education, leading to a reduction in educational quality. As international competition in educational services has become more intense, many countries have invested enthusiastically in university education in an effort to maintain their international competitiveness. Taiwan is no exception. To adapt to the strong competition that has accompanied

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membership of the WTO, Taiwan must immediately improve the quality of its university education (Chen and Ho, 2003).

The provision of education is a service industry characterized by a high degree of interpersonal contact (Chase, 1978; Katouzian, 1970); therefore, any exploration of the management of the education system must begin with a consideration of its service-industry attributes. However, despite the importance of the service sector, empirical research on new service development (NSD) is still sparse (Bullinger et al., 2003), and the studies that have focused on NSD (Alam and Perry, 2002; De Brentani, 1995) have largely neglected its application in the educational sector. This relative lack of attention is both surprising and a matter for concern specially in view of the fact that service design in education has been identified as a crucial factor determining educational quality (Oplatka, 2004). In particular, when planning and designing new departments in universities, few suitable models are available for reference in designing integrated models that are appropriate to practical requirements (Bullinger et al., 2003).

Universities must take care in planning new departments and satisfying their customers. Kanji and Tambi (1999) have noted that university customers include students, staff, parents, businesses, and government. To meet the demands of these customers in a competitive market, universities must promote themselves as offering high-quality education. In pursuit of this objective, unsatisfactory departments are frequently dissolved to allow new departments to introduce novel curricula, advanced technologies, first-class teaching, and improved service quality. This encourages able students to enroll and enables the university to provide graduates who meet modern recruitment criteria. This process of renewal and improvement is important to universities in the modern competitive environment. If planning and resources are insufficient, the process will fail to deliver satisfactory outcomes, thus leading to a lack of student enrollment and, ultimately, to adverse affects on the reputation and financial success of the university.

In the services sector in general, many service-design methods are available; however, these have seldom been used in the design and development of the education sector. Many studies have reported on the implementation of such methods as quality function deployment (QFD) and concurrent engineering (CE) in manufacturing industries and in NSD in general (Han et al., 2004; Stehn and Bergström, 2002; Kumar and Midha, 2001; Koufteros and Marcoulides, 2006). However, QFD is more complicated and less convenient than ‘design for X’ (DFX) (Hsiao, 2002). DFX emphasizes the consideration of all design goals and related constraints in the early design stage (Kuo et al., 2001) and allows the rationalization of services, associated processes, and systems (Huang and Mak, 1997). Effective utilization of DFX and CE in NSD can concurrently improve quality, costs, and cycle times (Dowlatshahi, 2001a, b; Huang and Mak, 1997). Against this background, the present study applies the DFX technique in a CE environment to the problem of establishing a new department in a university.

2. Literature review

2.1. CE

Prasad (1996) defined CE in the following terms: “concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related process, including manufacture and support”. In manufacturing, CE is predominantly used in product design (Dowlatshahi, 1996, 1997), and product life-cycle (Dowlatshahi, 2001a). The advantages of the use of CE are (Dowlatshahi, 1992, 1997):

- reduction in product development cycle time;
- avoidance of costly future redesigns;
- reduction in duplication of effort;
- better communication and dialogue;
- more efficient operations and higher productivity;
- overall cost savings;
- elimination or reduction of product recalls;
- lower maintenance costs;
- more reliable products;
- better customer satisfaction; and
- improved bottom line.

CE impinges on several factors in the establishment of new department in a university including customers’ demands, competitive advantage, market attractiveness, financial resources, and the quality of execution of the whole process of establishing a new department. To consolidate these dimensions, it is therefore important that a new
department be designed in a CE environment. With scrupulous planning and design, the new department will not consume valuable resources unnecessarily, and will simultaneously meet the demands of customers.

2.2. DFX

DFX was developed in the late 1970s (Kuo et al., 2001). Since the late 1990s, hundreds of papers have been published pertaining to the DFX applications in manufacturing (Rosairo and Knight, 1989; Kuo et al., 2001) and it is widely used in the development of new products (Huang and Mak, 1997; Kuo et al., 2001). DFX is a general term; ‘X’ can represent assembling, manufacturing, quality, and so on. The exact nature of the variable ‘X’ in any instance defines the focus of a DFX tool. ‘X’ has two parts X = x + bility. The suffix ‘-bility’ corresponds to the performance matrices (Huang and Mak, 1997). The ‘x’ part represents one or more business processes corresponding to one or more life cycles in product development (Huang and Mak, 1997). However, there have been few studies in the literature on the application of DFX in the design of a new department in a university.

DFX emphasizes consideration of all design goals and related constraints in the early design stage (Kuo et al., 2001). As such, DFX represents a suite of contemporary service-development techniques that can effectively be applied in service development to achieve concurrent improvement in quality, cost, and time to market. The technique allows the rationalization of services, associated processes, and systems (Huang and Mak, 1997). DFX has been applied in: purchasing (Dowlatshahi, 1992); product design in a designer–buyer–supplier interface (Dowlatshahi, 1997, 2000); logistics (Dowlatshahi, 1996, 1999); product life-cycle (Dowlatshahi, 2001a); and product safety and reliability (Dowlatshahi, 2001b). As Dowlatshahi (1992) has demonstrated, all aspects of DFX are integrated and can proceed simultaneously (see Fig. 1).

2.3. New service development (NSD)

The ability of a service organization to remain competitive in today’s technologically dynamic and market-driven environment is largely dependent upon the quality, cost, and timing of new service offerings (De Brentani, 1995; Dowlatshahi, 1997). A service organization needs to provide new services of high quality at low cost at the right time for customers. Many quality problems are recurrent and, to a great extent, these result from shortcomings in the development of new services (Edvardsson, 1992; Juran, 1992). In recent decades, manufacturing industries have developed many models, methods, and tools for the development of quality new products such as the spiral model (Bullinger et al., 2003), QFD, CE, business process re-engineering (BPR), and DFX. However, few of these are used in the design and development of service organizations (Bullinger et al., 2003), including those in the educational sector (Friel, 2000).

Effective utilization of CE and DFX to new service design and development will result in concurrent improvement in production innovation, quality, costs, and cycle times (Dowlatshahi, 2001a; Huang and Mak, 1997; Koufteros et al., 2001; Pillai et al., 2002). The core of the NSD process cycle is the ‘service concept’—which involves the service system, technology, people, tools, and the organizational context.

![Fig. 1. DFX in the CE environment framework (Source: Dowlatshahi, 1992).](image-url)
3. Model for establishment of a new department in a university

New service design and development involves the following steps (Alam and Perry, 2002; Edvardsson, 1997; Johnson et al., 2000; Murdick et al., 1990):

- concept creation;
- planning and analysis;
- design;
- testing and pilot run; and
- performance measurement.

The present study applies the NSD concept in developing a model for the establishment of a new department in a university. The model integrates the above steps into two stages: planning and design. These two stages are discussed further below.

3.1. Planning stage

To best meet consumers’ requirements of a product (service) from a design perspective, the physical elements of the product (service) requirements being linked to consumers’ perception of the product (Aitken et al., 2003; Lai et al., 2006). Therefore, the planning stage consists of four dimensions (see Fig. 2):

- confirmation of customer requirements;
- analysis of competition;
- strategic decisions; and

Fig. 2. Framework of university’ new department with the DFX in the CE environment.
confirmation of new department’s vision and mission.

Each of these is discussed below.

3.1. Confirmation of customer requirements
The most important customers of educational organizations are students and staff (Kanji and Tambi, 1999), and this stage ensures that the target customers are recognized. Customer interviews, customer surveys, and focus group methods are used to ascertain and confirm customer demands.

3.1.2. Analysis of competition
As noted above, competition among universities is becoming increasingly fierce. Strength, weakness, opportunity, threat (SWOT) analysis is therefore applied to analyze the university operations. The analysis reveals resources and competitiveness in relation to other institutions in terms of demographics, economic environment, political and legal environment, sociocultural environment, technological environment, and global environment. The purpose of this analysis is to allow the university to make use of its strengths, modify any weaknesses, master the available opportunities, and exclude any threats (Yang, 2004).

3.1.3. Strategic decisions
The analysis of the competition (above) allows the university to determine the departments that should be established to meet customer demand. By adopting an appropriate strategy, organizations can avoid potential problems and risks (David, 2001), and thus achieve competitive advantage. In contrast, incorrect decisions can cause inefficiencies and cost increases ultimately eroding organizational competitiveness (De kluyver, 2000; Quinn, 1980).

3.1.4. Confirmation of new department’s vision and mission
The new department requires an appropriate mission and vision to promote the reputation of the university, and to enhance cooperation and teamwork among staff and students. An organizational mission is a statement of the reason for the existence of that organization (Kaplan and Norton, 2001; Niven, 2002), whereas a vision provides a blueprint that points to the future development of the organization (Kaplan and Norton, 2001; Niven, 2002). Such a vision is usually expected to establish a framework of teamwork, resources, and support structures.

3.2. Design stage
In investigating the design stage, the present study used interviews and/or a questionnaire survey administered to 92 administrative executives or deans of several universities in Taiwan. The questionnaire used Likert-style scales from 1 to 7 to measure responses (with 1 representing very unimportant to 7 representing very important). The original questionnaire developed for the study included 14 dimensions that received very low scores (mean value < 6). These were eliminated from the final questionnaire, which contained 11 dimensions. The study then explored the parallel, and interactive relationships among these dimensions. The objective was to reorganize each practice in terms of the principles of DFX, and then to propose an integrated model of a new department in a CE environment.

As a result of the above empirical evidence and analysis, the dimensions can be summarized as follows (see Fig. 2):

- design of student recruitment;
- design of financial planning;
- design of marketability planning;
- design of teacher employment;
- design of education quality;
- design of curriculum planning;
- design of teaching/service process;
- design of physical/technical facilities;
- design of space planning;
- design of administration support; and
- design of evaluation system.

Each of these is discussed below.

3.2.1. Design of student recruitment
Students are the key customers of a school (Kanji and Tambi, 1999), and student tuition fees dominate the financial income of a university. This aspect of the design includes entry standards, enrollment requirements, class sizes, and student numbers. Class sizes and the number of students in a department should be approbated by the Ministry of Education (MOE) of Taiwan, and so must be planned in advance.
3.2.2. Design of financial planning
Universities must have adequate financial resources such that its departments can implement the institution’s mission and vision. This aspect of the design includes the cost of libraries and facilities, staff salaries, and personnel expenses.

3.2.3. Design of marketability planning
This dimension includes the design of marketing methods, marketing expenses, marketing the implementation unit, and the arrangement of personnel.

3.2.4. Design of teacher employment
This dimension includes the deployment of teachers, ensuring teaching skills, determining teacher numbers, and deciding teachers’ salaries.

3.2.5. Design of education quality
This dimension includes determining teacher/student ratios, deciding teaching hours, implementing plans for teaching improvement, and arrangements for education quality assessment.

3.2.6. Design of curriculum planning
This dimension includes curriculum development, designing overall credits (including compulsory and optional subjects), and curriculum planning and evaluation.

3.2.7. Design of teaching/service process
This dimension includes the standardization and simplification of teaching procedures, the determination of customer requirements and expectations, establishing the service level and quality standards specifications, and designing a monitoring-and-control system for teaching/service process quality.

3.2.8. Design of physical/technical facilities
This dimension includes the design of a friendly environment, facility layout, interior decoration, flow of people, and design of physical surroundings.

3.2.9. Design of space planning
This dimension includes the design of space for classrooms, learning, libraries, and facilities, and the allocation of research rooms for use by teachers.

3.2.10. Design of administration support
This dimension includes the design of an administrative framework, the framing of teacher and student satisfaction surveys, and planning of administration facilities.

3.2.11. Design of evaluation system
This dimension includes the design of performance-measurement systems and performance-measurement indicators.

If these dimensions are carefully planed and designed, erroneous planning and investment decisions will be avoided.

3.3. Summary of planning and design stages

As shown in Fig. 2, a carefully considered planning stage supports the design stage. The dimensions of each are interdependent and cannot be implemented separately or sequentially. Indeed, if attempts are made to implement the dimensions separately or sequentially, a lack of communication will lead to confusion and wasted effort (Anumba et al., 2002).
In a properly organized CE implementation, each department offers its suggestions thus providing the best framework in which to undertake group decision-making. It is apparent that the model must be implemented in a CE environment, and that the DFX and CE aspects must be fully integrated.

4. Case study

Ming-Hsin University of Science and Technology (MHUST) is a private university situated in northern Taiwan. The university was founded in 1966, and now has 17 faculty departments, 9 research centers, 17,000 students, and 588 staff members. The present paper took MHUST as an empirical case study to exemplify the successful implementation of the theoretical model described above. The case study presents the establishment, in 2001, of a new teaching department in leisure management within MHUST.

4.1. Implementation of planning stage

It will be recalled (see Section 3.1) that the planning stage of the model consists of the following steps:

- confirmation of customer requirements;
- analysis of competition;
- strategic decisions; and
- confirmation of new department’s vision and mission.
The implementation of these steps in the case study is described below.

4.1.1. Confirmation of customer requirements

Taiwan has beautiful scenery and the Taiwanese government is promoting tourism. However, many health clubs and amusement parks lack high-level managerial talent. Many people are employed in the leisure industry, but there is a scarcity of universities offering appropriate education in leisure management. MHUST assessed this situation and decided, in view of government policy and the demands of students and enterprises, that a new integrated teaching department should be established in the field of leisure management.

4.1.2. Analysis of competition and strategic decisions

In this case study, the second and third steps in planning competition analysis and strategic decision-making are considered simultaneously. MHUST undertook an internal and external environmental analysis and established that only two Taiwanese universities had departments of leisure management (DLM). It was therefore felt that establishing a DLM at MHUST had enormous potential in terms of attracting students. Furthermore, it was noted that MHUST is located near the Hsinchu Science Park. This means that the region surrounding the university has a high concentration of well-paid professional employees who work under significant pressure. These people and their families require suitable leisure activities, and it was therefore considered worthwhile to support the development of a local leisure industry by setting up a DLM in the local area.

4.1.3. Confirmation of new department’s vision and mission

The MHUST defined the mission and vision of the new department as described below. The mission of the new department was defined as:

To train polite and well-presented service personnel who: (i) are concerned about society; (ii) have humanistic attitudes; (iii) possess the ability to think independently; and (iv) are able to combine the theory and practice of leisure business.

The vision of the new department was defined as:

- To develop a leisure operation in accordance with Taiwanese characteristics (for example, pottery art, tea art) and local environmental resources (for example, forest and coast) to popularize healthy and meaningful leisure activities.
- To promote the ability of students to obtain employment by establishing multi-dimensional and diversified leisure operations as the core curriculum of the new DLM and management and planning as the supplementary curriculum of the new DLM.

4.2. Implementation of design stage

It will be recalled (see Section 3.2) that the design stage of the model consists of the following steps:

- design of student recruitment;
- design of financial planning;
- design of marketability planning;
- design of teacher employment;
- design of education quality;
- design of curriculum planning;
- design of teaching/service process;
- design of physical/technical facilities;
- design of space planning;
- design of administration support; and
- design of evaluation system.

The implementation of these steps in the case study is described below.

4.2.1. Design of student recruiting

The new department decided to recruit students for five classes every academic year, with each class containing 50 students. In Taiwan, class sizes and the number of students in a department must be approved by the Ministry of Education (MOE) of Taiwan, and these must therefore be planned in advance. With respect to entrance requirements, it was decided that students would apply for admission and then pass an admission examination. It was also decided that the number of enrollments each year would be adjusted according to demand for leisure-operation personnel.

4.2.2. Design of financial planning

Salaries of teachers are determined by MOE regulations. The following budgetary figures were determined:

- personnel expenses: NT$740,000,000
- scholarship funds: NT$49,000,000; and
- purchase of instruments and equipment: NT$7,000,000.
4.2.3. Design of marketability planning

Design of marketability planning included:

- the drawing-up of a budget (NT$2,000,000) for marketing (to be carried out by the enrollment department);
- taking part in school admission fairs frequently;
- promoting the new department in high schools; and
- marketing using relevant media to enhance the reputation of the new DLM.

4.2.4. Design of teacher’s employment

It was decided that the department would employ 16 full-time teachers—15 senior staff members with doctorates and one lecturer without a doctorate. In addition, the new department would utilize the services of several part-time teachers with practical experience in various aspects of leisure management, including:

- management of leisure centers;
- physical-health activities;
- management of natural resources;
- services provision; and
- pottery, tea art, and so on.

4.2.5. Design of education quality

To improve education quality, the staff/student ratio was set at 1:25. Scholarships were to be granted to excellent students, and guidance and assistance were to be provided for weaker students to encourage all students to work hard. In addition, an early-warning system of grades was instituted to avoid students being expelled due to bad grades. Finally, a system of counseling assistance was to be provided to monitor students who were facing psychological difficulties and to provide them with appropriate advice and spiritual guidance.

4.2.6. Design of curriculum planning

It was decided to base the curriculum planning design on 131 credit points (88 in the compulsory curriculum and 43 in the optional curriculum). This was to include:

- leisure agriculture (organic agriculture, leisure fishery, leisure farming);
- leisure art (pottery art, gardening, tea-art culture);
- leisure sports (practice of sports, water-leisure sports, physical-health management);
- leisure and natural resources (forest leisure operations, coastal leisure development, hot springs management); and
- leisure for those with special needs (children, women, the elderly).

Practical training in enterprises was to be provided during two summer vacations to ensure that practical experience was gained before graduation.

4.2.7. Design of teaching/service process

A questionnaire surveying administration and teaching was to be issued during each semester to identify the expectations and satisfaction of students. This questionnaire was to be the basis of assessment of progress in the new department’s teaching/service process. In addition, the Internet was to be utilized as an information resource and a means of network teaching.

Finally, cooperation with leisure enterprises was deemed to be essential to:

- identify demand for graduates;
- achieve timely modification of courses and teaching methods;
- identify purchases of appropriate equipment;
- meet the demands of all customers; and
- estimate overall effectiveness of the new department.

4.2.8. Design of physical/technical facilities

It was decided to provide the following facilities:

- a laboratory for physical-health management (providing equipment for sports testing and physical fitness);
- a video conference room (providing for a capacity of 150 persons);
- multimedia rooms;
- a reading room;
- a pottery art room;
- a tea-art room;
- a case-study room;
- a rhythmic gymnastics room; and
- a teachers’ study room.

4.2.9. Design of space planning

In designing physical and technical facilities, it was decided that there should be sufficient space for accommodation and leisure activities for the projected number of students, with allowance for space
for an increased number of students if demand led to an extension of the department.

4.2.10. Design of administration support

It was decided that all service processes should be computerized to reduce manpower and to promote service effectiveness. ISO-9000 standard operations procedures were to be established to enable teachers and students to be aware of the complete operational procedure of the department. In addition, arrangements were made for all instruments and equipment to be regularly maintained in good order to maintain the highest standards of teaching and research.

4.2.11. Design of evaluation system

It was decided to establish an effectiveness-measuring system of the administration and teaching. A questionnaire was designed to survey teaching quality and satisfaction of students during each semester. This was to include an assessment of individual teachers and staff members to ensure optimal performance.

It was decided to establish the following performance indicators:

- customer satisfaction: 90%;
- registration rate: 100%;
- e-teaching service: 70%; and
- performance evaluation of department: top 5.

4.3. Summary of case study

The theoretical model presented in this study applies the DFX technique while taking account of every dimension in the CE environment. By implementing this model in the establishment of its new department of leisure management, MHUST achieved the following apparent benefits:

- The department registration rate reached 100% in the three years since the model was first implemented in 2001.
- The performance of the department ranked first in the university on all measures (including student satisfaction, overall performance assessment, and so on).
- The department’s mission and vision were enunciated and communicated clearly, thus facilitating effective shared efforts among students and staff in achieving departmental goals.
- In accordance with enterprise demand and government policy, the new department has overcome deficiencies in the training of leisure managers, and has successfully met the demands of leisure enterprises.
- By emphasizing a combination of theory and practice, students have acquired relevant theory from university classes and practical skills through experience of working in business. (In this respect, it should be noted that higher education in Taiwan is notably deficient in combining theory and practice effectively.)

There are many service design theories and models are very plenteous, but each method has its own advantages and disadvantages. In Failure Mode and Effect Analysis (FMEA), DFX and QFD are most familiar applications for product design (Chen and Yang, 2004). FMEA is concerned with identifying the ways in which a product can fail and the effects of such failures. It also provides alternative solutions to prevent failures (Dowlatabadi, 2001b). But, the FMEA method is unsuitable for using this case study. QFD, a known tool is also often applied in service design and development, but statistical analysis, decisions in each service items correlation and calculation of its weight value are necessary completed. Therefore, QFD is more complicated and less convenient than “DFX” (Hsiao, 2002). Traditional product designs or service designs only consider such design factors as cost, quality, manufacture and reliability (Dowlatabadi, 2001b), however, could allow for the inclusion and trade-offs among such design factors as: market-ability, education quality, space planning and financial planning. These factors will be adjusted according to the points of view of the industry or the organization. Therefore, the case study applies DFX in a CE environment very cautiously to consider every key factor. The use of DFX in a CE environment has ensured success in the planning and design of the new department. If DFX is implemented separately from a CE environment, communication problems invariably arise which increase costs and decrease the ultimate service quality. The incorporation of a CE environment in the overall process ensures simultaneous consideration of service design and process design, thus, improving service quality and reducing re-design cost (Yan and Wu, 2001). The use of DFX in a CE environment, strictly planned and designed, has ensured that the implementation of the model in the case study has been complete and efficient. For the university, the ultimate result is that the institution
5. Conclusion

Competition in the higher education sector is becoming increasingly fierce. In such an environment, universities must learn from private enterprise in emphasizing excellent quality, low costs, and high efficiency. Higher education institutions also need to apply modern management methods such as total quality management (TQM), balanced scorecard (BSC), and Six Sigma. These integrated methods can promote efficiency and effectiveness, and thus maintain the growth and financial health of the institutions concerned. In addition, these methods also promote the wider reputation of the institution in the community.

The present study has addressed these matters by integrating two scientific approaches the DFX technique and the theory of CE to improve educational quality and management performance. The establishment of a new department must take into account many interdependent dimensions simultaneously. In presenting a complete model for the establishment of a new department within a university, the present study provides university administrators with a valuable cost-saving and time-saving approach to a crucial and complex challenge in modern education.

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