Developing Service Science Curricula for Industrial Engineering and Management Education in Taiwan

Kuo Ming Wang [1] **and Tsong Shin Sheu** [†2]
Department of Industrial Engineering and Management
Nan Kai University of Technology, Nan Tou County 542, Taiwan, Republic of China
Email: president@nkut.edu.tw[1]
tsheu@nkut.edu.tw[2]

Abstract. *Coping with the predomination of service sector in nation GDP and employment market, the industrial engineering education in Taiwan had already shifted its focus from manufacturing industry to service industry. Some of the core courses for services are such as services management, services marketing, consumer behavior, and customer relationship management. Nowadays, these courses are not sufficient to manage the problems that service industry faced including increasing the productivity of services and the need of service innovation. Industrial engineering education has to think services differently. Service science, a scientific study of service systems, is right now promoted by IBM and universities to approach the goal service industry toward. IBM and some universities around the world have developed the curricula for service science; however, the curricula development is just budding in Taiwan's universities. The aim of this study is to provide a directive suggestion for industrial engineering and management departments of universities in Taiwan if they hope to catch the development pace of service science. The authors summarized IBM and scholars' viewpoints on developing service science curricula; analyzed the curricula structure of industrial engineering and management departments; and finally made a comparison between the proposed service science curricula and the existing curricula structure of industrial engineering education to submit the directive suggestion. The results indicate that courses regarding people and culture need to be strengthened within industrial engineering education, and industrial engineering education has to systematically organize the courses into service science curricula.*

Keywords: *Service science, Service industry, Industrial engineering, Curricula*.

1. INTRODUCTION

Despite the service sector is currently prosperously developing and accounts for over two third of GDP and employment in many developed economies, investment in services represents less than one third of total R&D spending (RTI International, 2005). This insufficient R&D input causes the quality and productivity of service industry in a situation need to be further enhanced. For example, in the U.S., documents from large IT providers reveal that 10%-50% of general service business contracts do not meet client expectations; and in Japan, the profit margin acquired by service industry have declined much more than other industry (Abe, 2005). Thus, university has the mission to devote more efforts to prepare students fulfilling the sufficient competency to further improve the development of service sector.

In the past, the role of university was to prepare students to be the specialized problem solvers, who are sometimes called 'I-shaped' professionals for their knowledge depth. Thus, in the service economy, we have specialized departments to study the resource elements which were used to form service systems. For example, we have departments of management to study the whole businesses and organizations, departments of science and engineering to study technology, departments of social sciences and humanities to study people, and departments of information to study shared information. Obviously, this kind of education paradigm is no longer appropriate in preparing students to face such complex service systems, which need the competency from multiple disciplines to manage and operate. The increasing complexity of service systems requires university to prepare students to be adaptive innovators, who are sometimes called 'T-shaped' professionals. Adaptive innovators are still deeply educated in their home disciplines. However, they are also educated

†：Corresponding Author

to have the ability to think, act, and communicate across multiple disciplines. As the service economy continues to grow, T-shaped professionals will be in highly demand.

Facing the predomination of service economy, industrial engineering education in Taiwan has shifted its large proportion of focus to services. To cope with this change, the education concept of industrial engineering departments in Taiwan is trying to transform the knowledge and skills previously designed for manufacture to services. Some core service-related courses presented are services management, services marketing, consumer behavior, and customer relationship management. These courses train students to understand what service customers expect and their behaviors? to design the services, to operate and manage the services, and to measure the services outcomes including service quality, satisfaction and failure recovery. However, such a curriculum arrangement is still more like the 'I-shaped' training; a 'T-shaped' curriculum framework is yet formed within the industrial engineering and management (IEM) education.

2. BACKGROUND

Echoing the sustainability of service economy and demand of T-shaped professionals for service sector, Service Science, Management and Engineering (SSME), or in short Service Science, is emerging as a distinct field to look for a deeper level of knowledge integration.

2.1 The Definition of Service Science

2.1.1 Science

The service "science" concerns what service systems are and how to understand their evolution (Spohrer *et al*. 2007). Spohrer (2007), the Director of Almaden Services Research at IBM's Almaden Research Center in San Jose, California, refers "service science" to the mathematical modelling of service systems, and the social sciences that are relevant to understanding the human, organizational, and cultural aspects of services system. He also refers "service science" to understanding of the origins and life cycles of service systems, ranging from business components, to business models, to value networks of many businesses linked globally.

2.1.2 Management

The service "management" concerns how to invest to improve service systems (Spohrer *et al*.2007). Grönroos (1990; see also Grönroos, 1988) offers a fairly exhaustive definition of service management: Service management is:

(1) To understand the utility customers received by consuming or using the offerings of the organization and how services alone or together with physical goods or other kinds of tangibles contribute to this utility, that is, to understand how total quality is perceived in customer relationships, and how it changes over time;

(2) To understand how the organization (personnel, technology and physical resources, systems and customers) will be able to produce and deliver this utility or quality;

(3) To understand how the organization should be developed and managed so that the intended utility or quality is achieved; and

(4) To make the organization function so that this utility or quality is achieved and the objectives of the parties involved (the organization, the customers, other parties, the society, etc.) are met (Grönroos, 1990, p. 117).

2.1.3 Engineering

The service "engineering" concerns how to invent new technologies that improve the scaling of service system (Spohrer *et al*.2007). Spohrer (2007) refers "service engineering" to the design, development, deployment, operations, and maintenance of service systems based on IT, knowledge workers, outsourced organizational or business components – all configured to co-create, deliver, and capture value between a provider and a client.

2.2 Academies' Efforts on SSME Curricula

Under the promotion and support of IBM, there are more than 250 universities in 50 countries are teaching SSME courses, and there are 102 degree programs in SSME worldwide; furthermore, there are 27 service research centers worldwide and numerous SSME workshops (Fodell, 2009).

2.2.1 Efforts by U.S.

IBM is once again hoping to contribute to the promotion of innovation in services in the same manner as they promoting computer science in the 1950s, by linking up with universities and cultivating personnel who can lead new services on a global level. In May 2004 IBM hosted a particularly large-scale conference, and during this same year the company selected service science as a primary theme for information exchange and cooperation between 35 U.S. universities by participating in joint workshops and creating the future curriculum for service science. IBM also offered an IBM Faculty Award to the professor who accomplished the greatest achievement in service science research.

There are thought to be dozens of U.S. universities that are planning to adopt service science as a program, with the following five schools being the curriculum's foremost representatives: UC Berkley, MIT, Stanford, Rensselaer Polytechnic Institute (RPI), and Northwestern. Among these, UC Berkley has made the most headway in introducing service science with a service science program began in 2006. This program combined a variety of newly created service science-related courses with existing courses, and the program's overarching vision is to provide the students (masters-level) with "service science qualifications" (Abe, 2005).

2.2.2 Efforts by Japan

In Japan, the most active proponent of service science is IBM Japan. On September 9, 2005, IBM Japan's Tokyo Research Laboratory took concrete steps toward realizing this goal by bringing together MBA and Management of Technology (MOT) instructors from Japanese universities with the hope of conducting joint research. IBM hosted the Service Science Symposium at its Hakozaki office, inviting approximately 40 experts from various graduate institutions (Tokyo University, Tokyo Institute of Technology, Hitotsubashi University, Waseda University, Keio University, Japan Advanced Institute of Science and Technology, and Miyagi University) and companies (Hitachi, NEC, etc.).

In the Japanese academic world, Japan Advanced Institute of Science and Technology, Hokuriku (JAIST) is proactively engaging the issue of service science. JAIST also recently announced the syllabus for a graduate level course on the theory of service science. The Japan Society of Science Policy and Research Management (JSSPRM) is also an organization dedicated to the research of service sciences. At the JSSPRM's October 2005 research report session, a large number of reports concerning service science (such as regarding knowledge management) were presented, indicating that interest in service science is growing in Japan as well (Abe, 2005).

2.2.3 Efforts by Taiwan

In Taiwan, IBM also actively supports universities developing SSME researches and teaching. With IBM's support, Tsing Hua University established the first one Institute of Service Science (ISS) on 2008. ISS has four curricula modules as depicted in Figure 1.: Service Management & Innovation, Service Information & Management, Service Cultural & Society, and Industrial Cooperation. Besides, Yuan Ze University set up Graduate School of Services and Technology Management on 2007, Taiwan University and Chengchi University also set up research center to start researches and teaching of SSME.

In addition to the efforts by universities, societal institutions also devote to the development of SSME. Sayling Wen Cultural & Educational Foundation often offers the awards for theses competition. IDEAS, III (Innovative Digitech-Enabled Applications & Services Institute, Institute for Information Industry) hosted 2008 Service Experience Engineering International Forum at Nov. 28 in Taipei. Over 200 participants from practice and academy attend this forum. Topics include designing services, challenges on new service development, service innovation in living labs, surveying service innovation in mobility in Europe, mobile marketing in urban space (in example of mTourism), and a systematic engineering way to develop innovative service etc.. IEK, ITRI (Industrial Economics and Knowledge Center, Industrial Technology and Research Institute) is another important organization in promoting SSME.

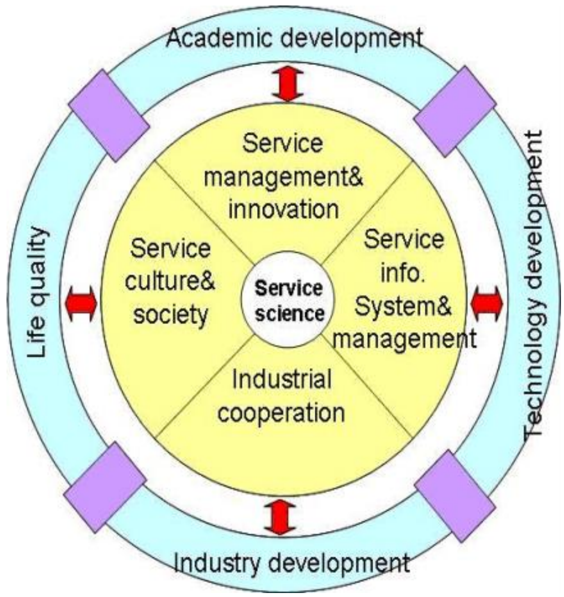

Figure 1. ISS's (Tsing Hua University) SSME curricula

3. DEVELOPMENT OF SSME CURRICULA

There were two types of SSME curricula classification. One is Resource Classification Scheme from University of Cambridge (IfM and IBM, 2008), and the other one is Discipline Classification System (Pinhanez and Kontogiorgis, 2008).

3.1 Resource Classification Scheme (RCS)

In a white paper of SSME, published by University of Cambridge, RCS was adopted to classify the curricula. RCS is based on the resources used to form services system. Four clusters of resources are whole businesses and organizations, technology, people, and shared information.

Table 1. shows the detail connotation of RCS. (IfM and IBM, 2008).

Table 1: RCS SSME curricula.

Categories	Connotation
1. Whole businesses and organizations	Studied primarily by schools of management, including courses of: • marketing • operations management • operations research and management sciences • supply chain management • innovation management
2. Technology	Studied primarily by schools of science and engineering, including courses of: • industrial engineering • computer science • statistical control theory
3. People	Studied primarily by schools of social sciences and humanities, including courses of: • economics • cognitive science • political science • design • humanities and arts
4. Shared information	Studied primarily by schools of information, including courses of: • communications • management information systems (MIS) • document engineering • process modeling • simulation

The following academic disciplines, which study some or all of the four resource clusters, are beneficial for the studies of SSME (IfM and IBM, 2008).

- Architecture and designed systems (1,2,3,4)
- Behavioral sciences and education (3,4)
- Cognitive science and psychology (1,2,3,4)
- Complex adaptive systems theory (1,2,3,4)
- Computer science and AI/web services (2,4)
- Computer supported cooperative work (1,2,3,4)
- Economics and law (1,3,4)
- Engineering economics and management (1,2,4)
- Experience design, theatre and arts (3)
- Financial and value engineering (1,2,3,4)
- Game theory and mechanism design (3,4)
- Human resource management (1,3)
- Industrial engineering (IE) and systems (1,2,3,4)
- Industrial and process automation (1,2,3,4)
- International trade (1)
- Knowledge management (1,2,3,4)
- Management of information systems (1,2,3,4)
- Management of technology& innovation (1,2,3,4)
- Marketing and customer knowledge (1,2,3,4)
- Mathematics and non-linear dynamics (1,2,3,4)
- Operations management (OR) (1,2,3,4)
- Operational research (OR) (1,2,3,4)
- Organization theory and learning (1,2,3,4)
- Political science (1,3)
- Project management (1,2,3,4)
- Queuing theory (1,2,3,4)
- Simulation, modeling visualization (1,2,3,4)
- Sociology and anthropology (1,2,3,4)
- Software metrics and development (2)
- Statistical control theory (2,4)
- Strategy and finance (1,2,3,4)
- Supply chain management (1,2,4)
- System design and software architecture (2,4)
- Systems dynamics theory and design (1,2,3,4)
- Total quality management, lean, six sigma (1,2,3,4)

3.2 Discipline Classification System (DCS)

Pinhanez and Kontogiorgis (2008) proposed the DCS for SSME curricula. They considered the SSME curricula as a union of more traditional service-related academic disciplines, including eight 1st-tier.disciplines and 75 2nd-tier sub-disciplines. The eight 1st-tier disciplines are general, service foundations, service engineering, service management, human aspects of services, service design, service arts, and service industries. Table 2 shows the DCS SSME curricula. Readers who are interested in the 2nd-tier sub-disciplines can refer to Pinhanez and Kontogiorgis (2008) for brief descriptions.

4. INDUSTRIAL ENGINEERING AND MANAGEMENT (IEM) EDUCATION IN TAIWAN

In Taiwan, the researches and teaching of IEM were divided into five sub-disciplines, including Human Factors Engineering, Operations Research, Information System, Production System, and Service System & Technology Management. According to the program report of IEM (Jiang, 2007), this paper summarized the foci of these five sub-disciplines in Table 3. Readers can notice that topics on service science have been one of the foci of sub-discipline Service System & Technology Management. The concerned topics include the research framework of service science, model of optimization, tools and methodologies in promoting service quality and efficiency, service innovation, evaluation of service productivity, risk control of service projects, computational organization theory, and inter-disciplines integration such psychology, sociology and management; however, no further details regarding the development of service science, especially the education of service science, had offered in the report.

Table 2: DCS SSME curricula.

Categories	Connotation
General	6 sub-disciplines, including: SSME Education; Research in SSME;SSME Policy; History of Services; Case Studies; Miscellaneous
Service Foundations	8 sub-disciplines, including: Service Theory; Economics of Services; Mathematical Models of Services; Service Philosophy; Theoretical Models of Services; Service Complexity Theory; Service Innovation Theory; Service Foundations Education
Service Engineering	13 sub-disciplines, including: Service Engineering theory; Service Operations; Service Standards; Service Optimization; Service Systems Engineering; Service Supply Chains; Service Engineering Management; Service Systems Performance; Service Quality Engineering; New Services Engineering; Computer Services; Information Technology Services; Service Engineering Education
Service Management	12 sub-disciplines, including: Service Marketing; Service Operations; Service Management; Service Lifecycle; Service Innovation Management; Service Quality; Human Resources Management; Customer Relationship Management; Services Sourcing; Services Law; Globalization of Services; Service Business Education
Human Aspects of Services	9 sub-disciplines, including: Service Systems Evolution; Behavioral Models of Services; Decision Making in Services; People in Service Systems; Organizational Change in Services; Social Aspects of Services; Cognitive Aspects of Services; Customer Psychology; Education in Human Aspects of Services
Service Design	5 sub-disciplines, including: Service Design Theory; Service Design Methodology; Service Representation; Aesthetics of Services; Service Design Education
Service Arts	5 sub-disciplines, including: Service Arts Theory; Traditional Service Arts; Performance Arts; History of Service Arts; Service Arts Education
Service Industries	17 sub-disciplines, including: The Service Industry; Utilities; Wholesale Trade; Retail Trade; Transportation and Warehousing; Information Services; Finance and Insurance; Real Estate and Rental; Professional and Technical Services; Management Services; Administrative and Support Services; Educational Services; Health Care and Social Assistance; Arts, Entertainment, and Recreation; Accommodation and Food Services; Public Administration Services; Other Service Industries

5. OBSERVATIONS AND SUGGESTIONS

The following are the observations we achieved in this study and the corresponding suggestions regarding the education of SSME in Taiwan.

The development of SSME is just in the germinating stage. In its current status, the main proponents are information-management-related organizations and / or individuals such as IBM-Taiwan, IDEAS, IEK, and scholars from and / or majored in information management. However, comparing the frameworks of RCS, DCS, and IEM education, we are quite sure of the successful embedment of SSME in IEM education, if some events are to be adjusted.

Table 3: The Research and Teaching foci of IEM in Taiwan

Sub-disciplines	Foci
Human Factors Engineering	Physical Ergonomics and Design; Cognitive Ergonomics and Design; Organizational Ergonomics and Design
Operations Research	Fundamental Theory; Algorithm; Analytic Method; Modeling; Optimization of Complex Problems; Logistics and Transportation Problems ; Supply Chains; Network Problems; Forecast Modeling; Industries Applications
Information System	Strategies, Administration, and Application of Electronic Business; Collaborative Business; Decision Support System; Data and Knowledge Management; Intellig ent System; Development, Establishment, and Administration of Information System; Human Machine Information System
Production System	Engineering Design and Plan of Products and Processes; Quality Engineering & Management and Reliability; Design and Analys is of Production System; design of Supply Chain and Logistics; Data and Knowledge Mining; Green Production System
Service System & Technology Management	Service System: Service Design; Service Resource Planning; Service System Analysis and Design; S ervice System Operations Management; Service System Automation and Computerization; Service System Performance Evaluation; **Topics on Service Science**; Technology Management: Technology Forecasting and Planning; Analysis of Technology Capability; Managing Technology Strategy and Manufacturing Strategy; Integrating Technology and Enterprise with Strategic Planning; Project Management of Technology; Managing New Product Developments and Product Innovations; Manufacturing Strategy and Production Management; Human Resource Management & Organization Management of Technology; Managing Technological Changes and Discontinu ities; Integration of Service System and Technology Management

Table 4 lists the correspondence between RCS and the sub-disciplines of IEM education. This is a somewhat subjective linkage made by the authors; but in general, we can allocate some of the sub-disciplines of IEM education to each of the four clusters of RCS. This means that IEM education may has resemble contents with RCS, but need to be reorganized in order to successfully form the curricula structure of SSME. The authors suggest re-positioning SSME to a sub-discipline level or replace the sub-discipline Service System & Technology Management with SSME. With the four clusters of RCS as standard, IEM has the opportunity to systematically reorganize the IEM courses into SSME curricula structure by treating SSME as a inter-sub-discipline, which integrate the original sub-disciplines of IEM.

Although we can make a close correspondence between RCS and IEM education, however, if we take one step ahead to refer to the DCS, some courses still need to be further appended into IEM education to form the complete SSME curricula structure. In general, those courses need to be appended belong to categories of general, foundations, and human aspects of services. IEM need courses to introduce SSME education and research, philosophy and history of services, economics of services, theoretical models of services, and service innovation theory. In addition, courses in the human aspects are specially needed to be strengthened. According to the authors' investigation toward the courses offered by Taiwan's IEM education, courses on human aspects occupy the lowest percentage (around 15%~16%), and most of them are human factors related. IEM education also needs additional courses to uncover individual's / organization's psychology, cognition, behavior, and decision making.

Table 4: The disciplines correspondence

RCS	IEM
Whole businesses and organizations	Operations Research, Production System, and Service System & Technology Management
Technology	Operations Research, Information System, Production System
People	Human Factors Engineering
Shared information	Operations Research, Information System

6. FUTURE RESEARCH

Recently, Choudaha (2008) highlighted a competency-based curriculum for a master's program on SSME. He reached 10 most important competencies and 14 courses domains may provide the most important competencies required for a graduate of the master's level interdisciplinary program in SSME. The 10 competencies were categorized into three clusters: Service Mindset, Integrative Competence, and Meta-competence; and the 14 courses were categorized into four modules: Contextual Foundation, Service Core, Engineering Concentration and Management Concentration, and Integrative Capstone. However, the competencies and courses domains were individually investigated and yet made a closely direct link in the investigation process. The authors are now engaging an investigation that closely links the required competencies and courses domains.

ACKNOWLEDGMENT

The paper is under the support of National Science Council, Taiwan: NSC 97-2221-E-252-013-MY3. The authors will thank the fund assistance from NSC.

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AUTHOR BIOGRAPHIES

Kuo Ming Wang is a professor in Department of Industrial Engineering and Management, Nan Kai University of Technology, Taiwan. He is also the incumbent president of Nan Kai, founding president of Yuan Ze University, Taiwan, and one of the founders of APIEMS. He received a Doctoral Degree from the Department of Industrial Engineering at Kansas State University, U.S.A. in 1975. He is a well known scholar and pioneer in lasting to promote the practicing of TQM, benchmark and innovation to strengthen the competency of government, education, and industry; and he has accumulated very rich experiences and reached a numerous achievements in practices. His email address is <president@nkut.edu.tw>

Tsong Shin Sheu is an associate professor in Department of Industrial Engineering and Management, Nan Kai University of Technology, Taiwan. He once was the subrogating president of Nan Kai from 1999/Dec. to 2001/Jan.; since 2001/Feb. till now, he is in the position of vice president of Nan Kai over 8.5 years. He has accumulated very rich experiences in education administration, and reached a numerous achievements. He received a Doctoral Degree from the Department of Industrial Engineering and Engineering Management at Tsing Hua University,Taiwan in 1997. His teaching and research interests include statistics, quality management, and service management and marketing. His email address is <tsheu@nkut.edu.tw>