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Systems Analysis of SDM Graduate Schools

Ex post and Phylogenic Approach to Map the System, Design, and Management Education

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***Abstract*—this paper is to provide the *ex post* analysis on graduate schools of System Design and Management (SDM), the brand-new type graduate schools for systems engineering education. By trailing historical background of system thinking, design thinking and management theory, the paper made it clear with phylogenic approach that graduate schools of SDM are built on well-balanced and hybrid integration of those three methodologies. And it also identified that these graduate schools are designed to manage teaching systemically and systemically problem-solving the issues of complex and interconnected system in the society.**

Keywords—system design and management; graduate school; system thinking; design thinking; management; systems engineering education

I. INTRODUCTION

This paper is to identify the current movement to launch graduate schools of system design and management (SDM) in the global context of two major concepts for solving of the real world problems; system thinking and design thinking. The authors of this paper particularly paid attention to the fact that those schools attempt to establish their conceptual platform by integrating system thinking and design thinking in the management realm for innovation.

Not passing the quarter-century since the MIT Engineering Systems Division and the Sloan Business School of MIT co-created the first-ever Graduate School of SDM in 1996, they are observing their original concept of systems engineering and management education traversing rapidly over the Pacific Ocean and bearing remarkable fruits of engineering education.

As of May 2014, there are four graduate schools of SDM. These schools became the leading cores for the innovation movements. Each graduate school of SDM has its unique history and background, but it seems to have an identical concept for enhancing technological and social innovation.

Beyond the original intentions which the founders of those graduate schools had in the beginning, it is necessary to analyze systemically and systematically on what these graduate schools stand as an academic eco-system. In this sense, this paper attempts to implement *ex post* analysis for what directions those schools have trailed and will go, while the founders had their own original concept for launching their schools. Thus this paper is epistemological and phylogenic with the authors' *ex post* literature surveys and systems approach.

This paper is by phylogenic approach through the academic fields of systems engineering and design thinking to identify inductively the conceptual foundation where and how the graduate school of SDM stands by looking over the current flows of academic fields of innovation studies. The faculties, staffs and students of graduate schools of SDM are immensely interacting for researches and classes. In that sense, the graduate schools of SDM as the whole formulate an eco-system in the systems engineering education. This paper describes the status quo of SDM education in the world, and why this happened from conceptual point of view.

II. MAPPING THE GRADUATE SCHOOLS OF SDM

A. Geographical Mapping

There are four graduate schools of SDM around the world.

In North America, there is the one and leading graduate school of SDM; MIT System Design and Management program (MIT-SDM) was created in 1996 by the MIT Sloan School of Management and MIT's School of Engineering [1]. This school is the oldest among four SDM graduate schools in the world.

Georgetown University, one of the oldest universities in the United State, has the Systems Design and Management program within the master course of Professional Studies in Technology Management. But this is not an independent graduate school of SDM and rather a part of life-learning program of technology management program [2].

In Asia, there are three graduate schools teaching SDM. Keio University, one of oldest universities in Japan, celebrated its 150th anniversary in 2008 and launched the Graduate School of System Design and Management (Keio SDM) [3].

Singapore has two emerging graduate schools of SDM. At first, the Faculty of Engineering, National University of

Singapore (NUS) started in January 2005 the Engineering Systems Initiatives (ESI). The ESI prepared for the Master of Science course in Systems Design and Management in the NUS Division of Engineering and Technology Management (NUS-SDM) [4]. Following the NUS SDM, the Singapore University of Technology and Design (SUTD) with collaboration of MIT-SDM launched in 2011 the MIT-SUTD Dual Masters' Program. This is a joint education course that master students spend one year at MIT followed by another year at SUTD for master of engineering [5]. This dual degree program was extended in February 2014 to include the Singapore Management University (SMU) for inaugurating the tripartite undergraduate dual degree program in technology and management [6].

As for extension to the undergraduate engineering education, the University of Tokyo, the leading national university in Japan, started in 2013 the System Design and Management course as part of Department of Systems Innovation, Faculty of Engineering. But this course does not constitute the school and only for undergraduate education [7]. The Tokyo Metropolitan University has the Graduate School of System Design. However, this school is targeting systems and engineering studies and not including the element of management [8]. Keio University has also graduate school of system design engineering in the Faculty of Science and Technology, but not identical teaching concept with the above graduate schools of SDM [9].

In Europe, Middle East and Africa, the authors cannot specify graduate schools with the mane of system design and management. It does not necessarily imply that there is no graduate school of SDM in these regions, but further search will be expected.

In the Netherlands, the Eindhoven University of Technology has the post-graduate program named as the Post-MSc Architectural Design Management Systems (ADMS). However, this program deals mainly with architectural and civil-engineering design [10].

Table I shows the locations and basic features of four graduate schools of SDM.

TABLE I. GRADUATE SCHOOLS OF SDM (AS OF MAY 13, 2014)

School Names	Location, Launch Year and Basic Features		
	Location	*Year*	*Basic Features*
MIT-SDM	Cambridge, MA, USA	1996	● 13- to 24-month graduate program. Core courses are system architecture, systems engineering, and system and project management.
Keio SDM	Yokohama, Kanagawa Prefecture, Japan	2008	● 24-month master program and 36-month doctoral program. ● Core courses are systems engineering, design project, and project management.
NUS-SDM	Singapore	After 2005	● 3 semesters recommended as master program. ● Core courses are systems architecture, systems engineering, knowledge management, and systems engineering project management.
MIT-SUTD Dual Masters' Program	Singapore	2011	● 1st year in MIT and 2nd year in SUTD for master program. ● Connected to PhD Program of Engineering Systems and Design

B. Conceptual Mapping

A school functions as a social system [11] for knowledge creation and management, and a graduate school of SDM is no exception for this recognition. A graduate school of SDM is a human-centered system for knowledge creation and management on engineering education.

At the same time, four SDM graduate schools identified in the previous section are also considered to compose a system of systems to create synchronized concept of system design and management by interrelating themselves academically[12]. Since a system is a set of interrelated elements, plural systems function as system of system if an element of that system is a sub-level system [13].

The authors applied the systems-approach [14] for identifying purpose, function and behavior of the graduate school of SDM as system of systems from literatures describing four SDM graduate schools [1][3][4][5][15].

- *Purpose*: solving large-scale and complex systems engineering problems; and developing the next generation leaders for creativity and innovations.
- *Function*: integrating approaches based upon systems engineering, design thinking, and management; crystalizing them into a discipline to be ported, taught and adapted for the ongoing challenges; and encouraging leadership and entrepreneurship in technology, design and management.
- *Behavior*: addressing to real problems and enhancing innovations in the society; and teaching systematically an integrative holistic view to solve large-scale and complex challenges.

According to the literatures search, it is uncovered that the graduate schools of SDM simultaneously make emphasis on solving the on-going large-scale and complex problems by integrating systems engineering, design thinking, and management into one discipline of the system-design-management. By this emphasis, those schools are designed to teach their graduate students as global leaders how to enhance innovations systematically and systemically (Fig.1).

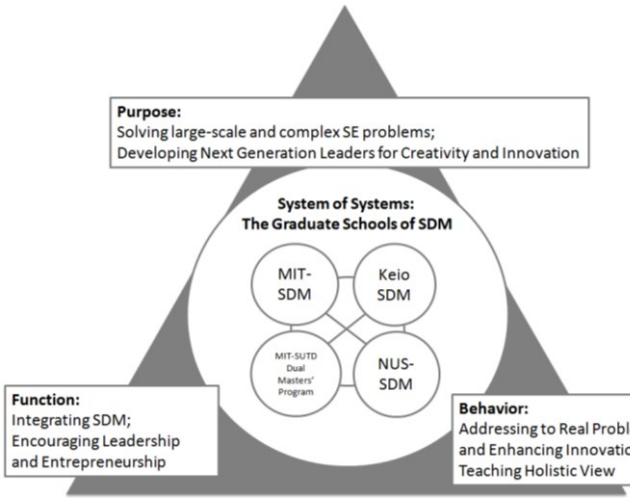


Fig.1 System of systems: Graduate Schools of SDM

III. THEORETICAL FOUNDATION OF THE SDM SCHOOLS

The graduate schools of SDM are selectively integrating methodologies of systems engineering, design thinking, and management in particular manner, since they as a system of systems are conceptually adapting to build their self-learning model. In this section, the authors make the discipline-by-discipline analysis on what elements of each discipline are inherited; system thinking, design thinking and management theory.

A. System Thinking

There are three major conceptual flows from system thinking influencing conceptualization of the SDM methodology

The graduate schools of SDM put the artifacts at the center for their studies. The sciences of artifacts are no doubt one of their academic foundations, since the system thinking considers that the systems need to be constructed and their behavior observed to understand them [16].

Besides the system thinking started from H. Simon (1969), there are two significant methodologies taught in the graduate schools of SDM; the system dynamics founded by J. Forrester [17][18] and the system thinking of P. Senge (1990) [19] later developed to his U Theory.

These three schools contributed to construct the holistic and systemic view when the SDM graduate schools teach their students who tackle with the on-going challenges of social systems.

B. Design Thinking

It is not often that the design thinking is mentioned as the core discipline to be taught in the graduate schools of SDM. However, the design thinking is penetrating to their research and education in depth, since the design thinking is the way to transform existing conditions into preferred ones in the society.

The design thinking is the intellectual activity that produces material artifacts for the society [16]. Thus the design thinking is one of major methodologies to consider how system analysts apply systems engineering for fixing 'wicked' problems [20][21].

There is a strong current in the discourses of design thinking to connect the design thinking to the innovation theory [22][23]. This movement also impacts the graduate schools of SDM as they very often refer to the social designs for innovations [1][12].

Johansson-Sköldberg et al. (2013) divided the design thinking in the broad sense into two academic thoughts; the "designerly thinking" and the "design thinking as a fad". And it highlighted several elements of the designerly thinking as four core concepts; the science of the artificial, reflection in action, designerly ways of knowing, and creating the meanings [24]. These elements are well blended in the primary purpose of the graduate schools of SDM.

C. Management Theory

The Graduate schools of SDM largely incorporate the management theories and the managerial ways of knowledge to their teaching courses in three ways.

Firstly, as some SDM schools have the origin of the school of management of technology as MIT-SDM, the technology and management theories are taught in the SDM schools.

Secondly, the project management theory is one of main courses in these schools. For example, Keio SDM teaches PMBoK as one of its important methodologies for integrative education of system engineering and design project.

Thirdly, the design thinking has roots in the field of management theory and the SDM schools are heiresses of these heritages. Business managers link design thinking closely to their practices of management strategies [25][26] and the SDM schools teach them in that way, too.

IV. CONCLUSIONS AND FURTHER RESEARCH AGENDA

A. Conclusions

The authors applied the *ex post* systems approach to uncover what the graduate schools of SDM successively established from 1996 to 2011 created as an academic eco-system at this moment, beyond the one which founders of those schools had originally intended.

The graduate schools of SDM formulate a system of systems with merging core concepts of the system thinking, design thinking and management theory into one inter-disciplinary methodology for innovations. As the authors' *ex post* survey in this paper, among several waves to absorb selectively these three methodologies, the author made it clear that the platform for their systems engineering education emphasize the social design with strategic

management to fix the large-scale and complex problems of social systems.

B. *Further Research Agenda*

The authors expect further researches will be conducted in two directions.

One direction is for mapping conceptually further engineering and design schools than the SDM graduate schools in the strict sense.

Another direction is for uncovering the concrete contents of the SDM methodology if it is successfully established as one discipline.

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