EDUCATIONAL CURRICULUM FOR MULTI-DISCIPLINARY SYSTEM DESIGN AND MANAGEMENT

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ABSTRACT

"System Design and Management" program, a study that integrates humanities and sciences by crossing many disciplines, is essential to foster talented persons who can lead in the development and operation of large-scale complex systems that are symbiotic, safe and secure. The subject of the new graduate school education is large-scale complex technological and social systems, with an education curriculum that provides practically oriented lectures through which students can acquire the capacity to consider systems, the faculty to design systems in line with system life cycles, and the ability for system management. By collaborating with industries and related stakeholders such as domestic and international educational research institutions, we designed an educational curriculum. As for the establishment of the graduate school in April 2008, the educational curriculum was formed to provide students with opportunities to acquire must-learn capability and knowledge that were classified into six groups. The validity of the education method was confirmed based on verification of the students' self-evaluation and evaluation by the external evaluation committee after the first two years of graduate education.

Keywords: System design and management, Multi-disciplinary, Large-scale complex system

INTRODUCTION

The majority of universities and graduate schools focus on education in single academic studies (referred to as disciplines below) and conduct research that discovers, illuminates and forms universal knowledge through planned probes into unknown phenomena. Traditional education and research of this type have for a long time produced human resources with advanced expertise. However, the specialization and fragmentation of learning mean that this traditional approach no longer lends itself to develop human resources capable of handling issues that straddle academic fields (Yoshikawa, 2008).

Recent commercialized systems generate problems that expertise in a single field or fragmented learning has difficulty dealing with. For example, the complexity involved in solving unforeseen accidents and breakdowns that occur in the operation of a power generation system or space system or the intricate nature of safety design involved in the development of automobiles or robots. These problems are often caused by the large scale and complexity of current systems (Leveson, 1995). That is because the safety issues that each system faces and the global environmental problems that they involve cannot be resolved by devising systems that cope with each problem separately. Cross-sectional learning structured for designing comprehensive systems based on education from a system integration viewpoint is indispensable to appropriately capture safety issues, global environmental issues, the system and the relationships of all the elements that make up that system, that is the complex interactions between values of vastly varying categories and scales as system relationships. It is hard to say that universities and graduate schools offer education that provides methodology to solve the problems that products developed by the industrial world generate in their use.

Education conducted at the university and graduate school level must at all times meet the demands of industry. In "Results of a questionnaire on human resources sought by corporations," (Japan Business Federation, 2004) the Japan Business Federation Committee on Educational Issues gives a list of expectations summarized in Table 1 regarding workforce development at science and technology departments at universities and graduate schools. The table lists the five most common responses in the results of a questionnaire targeted at 520 corporations to discover what sort of human resources in the engineering field they wanted universities and graduate schools (science and technology departments, discipline) to produce from a standpoint of hiring. Corporations could select from among three different responses. The results indicated they wanted universities and graduate schools that could produce human resources able to make the most of advanced technical expertise, create and manage future generation systems capable of coping with the rapidly changing conditions of present-day society.

Table 1. Expectations of Universities and Graduate Schools

Response	No. of Companies
The firm acquisition of specialist knowledge by students	340
Training in the assembly of knowledge and information and the derivation of one's own thoughts	287
The acquisition of fundamental knowledge of other areas relating to one's own specialist field	231
To provide education with an awareness connected to the real world in addition to theory	162
To give students the experience of assembling teams and tackling specific challenges	119

Taking this social background into account, Keio University established the Graduate School of System Design and Management (referred to as SDM below) in April 2008. The graduate school offers applicants with work experience in special fields a unique hands-on educational curriculum to foster human resources that can design large-scale complex systems for meeting the symbiotic, safe and secure requirements of society. The large-scale complex systems mentioned here are not limited to power generation systems or space systems but also include social systems such as financial, medical, local community, business organization and NPO organization systems.

Our goal is to build a System Design and Management program (referred to as the SDM program below), an academic discipline for creatively designing and effectively managing large scale complex systems, as part of graduate school instruction to foster human resources capable of leading the building and operation of large-scale complex systems. This paper will introduce the design of educational curriculum we have conducted to achieve our goals and the result obtained. Assessments made by students, thoughts thereon and future objectives will also be discussed.

DESIGNING A GRADUATE SCHOOL

In designing the SDM graduate course, we conducted interviews targeting persons involved in large-scale complex systems both in Japan and overseas on the objectives related to the development and operation of large-scale complex systems and what they saw as the requirements of a graduate school education. The results of these interviews regarding demands on a graduate school education roughly coincided with the data in Table 1. The structure of our graduate school education was designed on the basis of design procedures in large-scale complex systems used in systems engineering developed in Europe and North America, similar systems used by the Japanese industry for automobiles, robots or plants, system design methodology (Yoshida, 2008) (Matsuoka, 2008) created using "System design: Paradigm shift from intelligence to life" in Keio University's 21st century COE program as well as know-how and procedures required for social system design and management. The master's course emphasizes interactive tuition involving teachers and students or student groups, the objective of the course is to foster human resources capable of leading the construction and operation of large-scale complex systems through specialist graduate school type instruction. The doctoral course places a premium on research with the objective to develop specialists in system design and management studies. Details of educatoinal flow are given below.

(1) Designing curriculum

An SDM course is built as an educational system while the educational curriculum is overhauled to determine the skills that students must acquire to handle large-scale complex systems based on social and industrial objectives as well as demands regarding a graduate school education to enable students obtain those skills. We will collaborate with Japanese and overseas universities and graduate schools as required regarding the education in single disciplines.

(2) Implementing education

The SDM course will focus on hands-on learning and group learning targeting unsolved problems in society. In addition, SDM seminars and lectures will be targeted at people with employment experiences in industry rather than students to foster leaders that can manipulate large-scale complex systems, as well as identifying social problems and the demands of graduate school education. To enhance the teaching skills of teaching staff, opportunities for faculty development will be frequently provided.

(3) Disclosing results and identifying problems

Skills acquired by students in the course of graduate school studies and know-how learnt by teaching staff should be reported to and evaluated by stakeholders. Assessments should also be made by the students enrolled in the SDM graduate course and these assessments should be analyzed to find problems and make it possible to improve our education.

The above scenario is not a single cycle; in each of the steps of (1) and (2) under (3) Disclosing results and identifying problems work to further develop SDM courses and regularly make improvements of graduate school studies. It is a spiral up scenario intended to achieve set goals.

ESTABLISHING A GRADUATE SCHOOL

In establishing an SDM graduate course, interviews were conducted among 100 or more industries in Japan and overseas to find the problems in the industry and determine the demands placed on a graduate school education. As a result, Figure 1 indicates the six types of skills and knowledge that students were expected to acquire in order to handle large-scale complex systems. The horizontal axis indicates the range of discipline and the vertical axis shows the scale and complexity. Thus leaders handling large-scale complex systems require system design ability and system management ability and to acquire such capacity, they need system thinking ability and communication ability as a basis. This means that leaders must acquire expert knowledge in a field and a basic knowledge of areas related to such expert knowledge. A definition of such abilities and knowledge is given below.

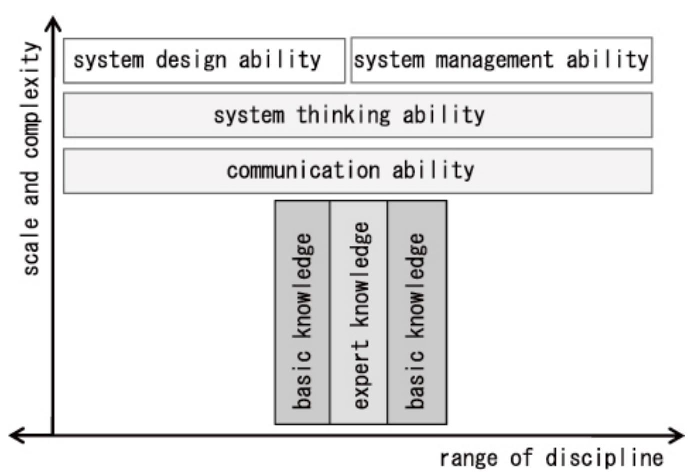

Figure 1. Six Types of Abilities and Knowledge

(1) System design ability:

Ability to grasp the true problems and demands of users, customers, society, environment and other stakeholders and propose creative solutions while taking into account the overall consistency throughout all stages from conceiving the system through to development, operation and disposal (design includes all types of structure and solution proposals including technical system design, artistic design, organization design, social design and up to grand designs of management or policy)

(2) System management ability

Ability to proceed in a consistent manner with system design, system management and operation to satisfy the demands of users, customers and other stakeholders and cope with changes during progress of the project and its life cycle

(3) System thinking ability:

Ability to pay attention not only to independent events but also to the mutual dependency and interconnectedness of each event to grasp the overall system and the true nature of its problems comprehensively, systematically and in a cross-sectional manner.

(4) Communication ability:

Ability to convey your own thoughts to another party, understand what another party thinks and build teams with a great variety of human resources to solve problems

(5) Expert knowledge:

Thorough knowledge in a science or social science field (knowledge in multiple fields is better)

(6) Basic knowledge:

Basic knowledge in fields related to expert knowledge

The following describes learning at a graduate school established by selecting elements or integrating elements to achieve an objective.

Curriculum

Table 2 provides an overview of established lecture subjects. Lecture subjects that relate to abilities and knowledge that students must acquire through learning are marked o and those that have an especially strong relationship are marked ◎. Lecture subjects not related to those that a student must attend due to specialization are marked △. Table 3 lists the names of subjects for recommended subjects and elective subjects.

Table 2. Overview of Established Subjects

	Required Subject								
	Core Subject								
Ability and Knowledge	Introduction to Systems Engineering	System Architecting and Design	System Integration	Project Management	Design project ALPS	System Design and Management Researc	Recommended Subjects (Technology/Social Skillx)	Elective Subjects (Technology/Social Skills)	Subjects from other Departments and Unive
System Design Ability	ก	ก	ก	○	ก	ก	○		
System Management Ability	○	○	○	ก	ก	ก	○		
System Thinking Ability	ก	ก	ก	○	ก	ก	○	○	
Communication Ability				ก	ก	○	ก	○	
Expert Knowledge					○	ก	ฆ	ฆ	ก
Basic Knowledge					○	○	ฆ	ฆ	ก

Table 3. Recommended Subjects and Elective Subjects

Recommended Subjects	Technical	System Environment
		Human Factors
		Risk Management of Engineering System
		Dependable Systems
		System Life
		Digital Manufacturing System
		Model Based System Engineering and Architecting
	Social Science	Introduction to International Affairs
		Communications
		Human Relations
		System Management
		Ethics for System Design Engineers
Elective Subjects	Technical	Mathematical Modelling and Statistics
		Mathematical Technique of Prediction and Optimization
		Mathematical Technique of Dynamical Analysis and Control
		Database Management System under Network Environment
		Software Safety Engineering and Reliability
		Software Engineering
	Social Scienc e	Fundamentals of Accounting, Marketing and Economics
		Introduction to Legal Issues forEngineers
		System Simulation Technique

		Global Standardization Strategy
		Methodology of Creative Decisoin Makings
		Business Intelligence
		Design Philosophy for Policy and Regulation
		Political Economy of International Systems
		Methodology and Management of Socio-Critical System
		Special Lectures

The four abilities that a student must acquire are taught primarily by building a foundation formed by required subjects that is strengthened by recommended subjects. The combination of recommended subjects and elective subjects differs depending on what a student must learn depending on the respective field. Since there are multiple disciplines, students are allowed to attend other graduate school or university lecture subjects other those in the SDM course to acquire expert knowledge and basic knowledge. Especially, the SDM collaborate with other graduate schools in Keio University such as the Graduate School of Science and Technology and the Graduate School of Business Administration to provide students with opportunities to complement lecture subjects.

Excluding some lectures, most lectures offer two credits per subject. Figure 2 shows the framework of master's course curriculum. Values in ( ) give the number of credits required for a degree. The requirements for completing a master's course is to acquire 30 or more credits for lectures out of which 8 credits should come from core subjects, as well as 4 credits for design project ALPS (Active Learning Project Sequence referred to as ALPS below) and 2 credits for system design and management research. Also, 6 or more credits in required technical subjects, 2 or more credits in required social science subjects or 2 credits in required technical subjects and 6 or more credits in required social science subjects enables a student to acquire a master's degree. To enable more active participation from students, lectures, which are 90 minutes long and involve 14 sessions, are often held in the form of group learning, exercises or discussions. To enroll students from overseas, required lectures are not only offered in Japanese but also in English.

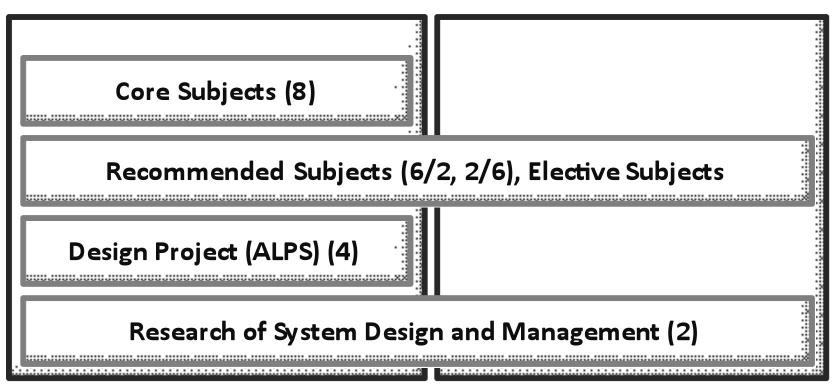

Figure 2. Framework for the Master Course Curriculum

The educational curriculum of required lectures is described below. To ensure that lectures provide basic knowledge that adheres to international standards, four textbooks that conform to Certified Systems Engineering Professional (referred to as CSEP below), by the International Council on Systems Engineering and Project Management Professional (referred to as PMP below) by the Project Management Institute. These are books (Forsberg, 2005) used in all shared core subjects, books (INCOSE, 2007) used in 3 subjects excluding project management, books (PMI, 2008) used in project management and books (Ishii, 2008) for ALPS.

Since many of the instructors possess experience in large-scale complex systems as well as know-how and capacity in this field, their lectures and the teaching format will reflect that experience. For example, in “System Integration” a shared core subject, the textbook introduces processes and relationships that are about to become part of the system of the systems engineering field. The instructor will then introduce problem solving cases from his/her own experience with automobile and satellite development to describe the gap between theory and actual experience. Students will through these lectures learn system integration differences between mass production of automobiles and satellites, in addition to design procedures developed in Japan.

Introduction to Systems Engineering

The lectures discuss basic strategic systems engineering using the V-model in a system development process. Consequently, lectures and exercises deal with systems thinking, requirement analysis, function and physical partitioning, architecting and other concepts to teach the basics of system design and management for coping with society's widely varying requirements. In practical training, students are divided into teams of a few members to experience development of actual systems such as "an automatic cleaning system that can be remotely controlled when the user is not home.” A number of instructors are present at these lectures and a student is asked to interview an instructor taking the role of customer to determine problems and demands to create a specification that covers all development processes from identifying requirements and through to delivery to develop a system that conforms to the development process. The teams take the roles of competing companies developing an actual system. Figure 3 shows a remotely controlled cleaning system developed by a team. The left figure shows the screen for remotely controlling the service and the figure on the right shows the developed cleaning system using Roomba 577 manufactured by iRobot and its configuration.

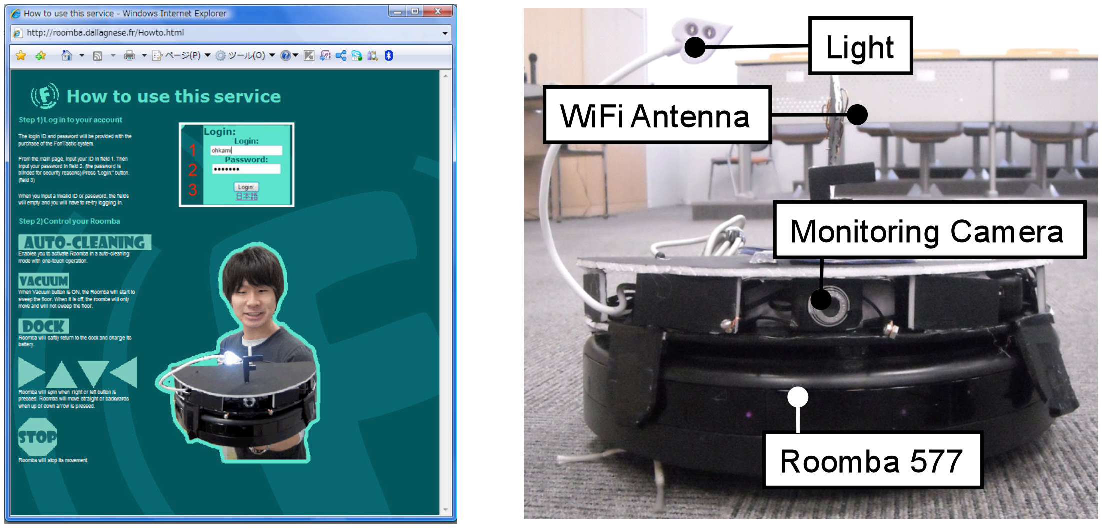

Figure 3. Automatic Cleaning System

System Architecting and Design

These lectures deal with visualization from multiple viewpoints, problem solving structure and detailed structure architecting and design that meet society demands. Group debates are held on the architecting and design of research subjects studied by the students.

System Integration

The lecture describes learning systems of processes for dissembling objects into their constituent elements and for positively integrating those elements into a system. Thus, the lectures describe how to create the required specifications, analyze, design, test and verify, as well as check the validity of required specifications. Group exercises for hands-on training and debate are provided as part of the lectures.

Project Management

The lectures deal with the basics of project management. Lectures and exercises are provided for managing large-scale complex systems, logistics (personnel and procurement) both basics and practice and techniques for cross-management and project management. Figure 4 shows an example of a project exercise of building a tower using paper. The students were divided into small teams where members acted out specific roles such as project manager to make preparations and actually construct a tower according to management processes that comply with PMP. This exercise pitted the teams against each other to build the highest and most stable tower within a set budget and before the deadline to assess the results of each project manager. The price of paper used and the hourly work rate for each student had been determined in advance.

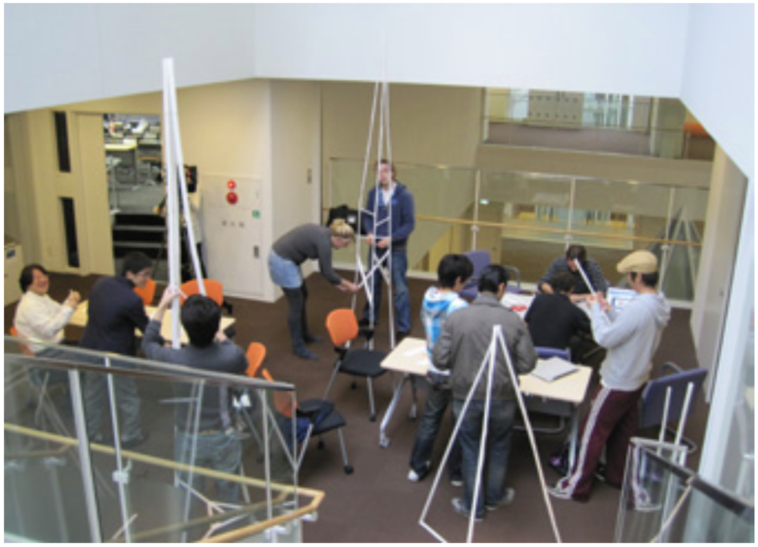

Figure 4. Project Exercise of Building a Tower Using Paper

Design Project ALPS

Conducted in English, this is an international group project developed in collaboration with Stanford University and Massachusetts Institute of Technology. This course takes up problems such as “Enhancing Senior Life in Japan” (fiscal 2008) and “Sustainable Community” (fiscal 2009) and conducts four or five workshops (each a 2-day event) annually of group training involving teams of 5 to 8 students to provide experience in all processes involved in a system life cycle. The final session presents a system proposal, which is debated. Figure 5 shows the work flow of group training in the annual workshops. Instructors from the three universities view the ALPS lectures via TV conferencing and makes adjustments to the lectures and procedures almost daily. Focusing on shared core subjects, this course also involves many closely related subjects so that students grasp the lectures focusing on this subject and the know-how provided by the lectures can be applied to the subject. For details on this course, see the brochure (Ishii, 2009).

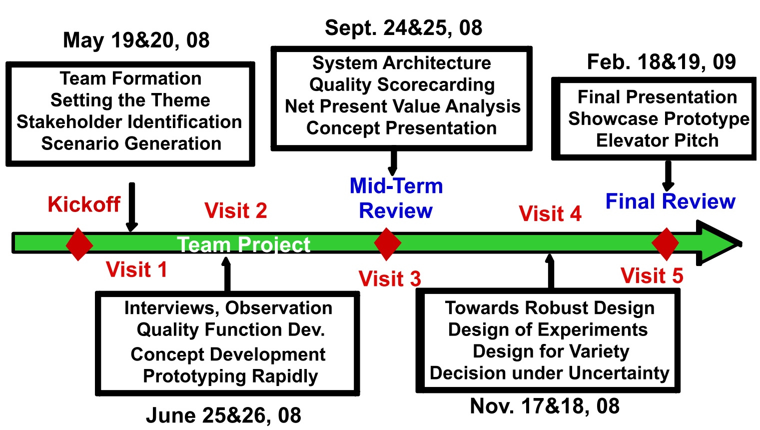

Figure 5. Work Flow of Group Training in the Annual Workshops

System Design and Management Research

This research program is the equivalent of a master's course. Still, the course differs markedly from the individual type of research that used to be the norm. Research is now conducted in groups that study a field as projects in a cross-sectional manner and conducted conforming to the demands of society such as safety, security, symbiosis and social symbiosis. Students compile the part of the project he/she has managed to produce a thesis.

Students

The university conducts student enrollment campaigns for the SDM course among academy, industry and government organizations and requests industry to send adult students. As a result, we are now attracting students via three annual entrance examinations according to our original scenario. The students in the program represent diverse backgrounds in age, field and nationality. In fiscal 2008 and 2009, we enrolled students both during the spring and autumn term. Master course enrollment in fiscal 2009 numbered 138 students and there were 46 doctoral course students. The age of our students range from 20 to 60 and the average age of master's course students is 38 and 42 for doctoral course students. Their original faculties included science, law, political science, literature, commercial science, agriculture, physical education. Many of the students possessed professional experience, 66% of master's course students and 89% of doctoral course students. Students with job experience came from a wide variety of fields: manufacturing, communications, consulting, information, aerospace, finance, real estate, government and municipal offices, construction, energy, systems, medicine, mass media and publishing and the legal profession (Figure 6). The ratio of students with foreign nationality including students that come from overseas is now 20%. As planned, we have been able to create an environment where students with widely different job experiences can meet and associate with our diverse and talented instructor corps.

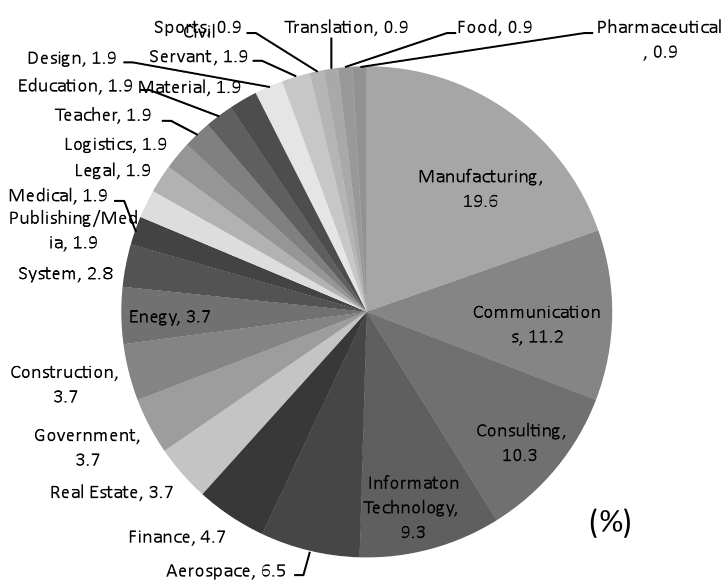

Figure 6. Occupation Distribution of Students with Business Experience

Teaching

Many of our teaching staff have worked with large-scale complex systems and this experience is reflected in their teaching. And since many of the students have work experience and plenty of expertise, the lectures often introduce measures to solve specific industry problems and many lectures take the form of a discussion. For example, an instructor with a background in financial systems might may ask students questions like “What kind of verification methods are there for a social system?” or “What are the merits and demerits of the methods introduced?” to intensify the discussion during a lecture. In addition, out of respect for the independence of the students, they will be encouraged to hold their own lectures or invite students with special expertise or lecturers from outside to hold lectures.

To enhance the capability and know-how of the instructors, faculty development meetings will be held two or three times a month. Each instructor should report what he/she has learnt or problems he/she has experienced in the course of teaching so that they can be shared and regularly discussed to enhance the level of teaching and research.

To provide adult students who find it difficult to attend classes in the daytime with opportunities for study, they are allowed to attend shared core subjects in Japanese on Saturdays or on weekday evenings (19:00 – 20:30). On the other hand, overseas students are all fulltime students and should attend shared core subjects in English on weekdays. We also contribute to the fostering of leaders in the design and management of large-scale complex systems by providing industry personnel not enrolled as students the opportunity to attend related external SDM seminars and short study courses. Such measures help to identify the problems of industry and the demands on graduate school education.

Disclosing results and identifying problems

The results of learning will be disclosed and we offer industry opportunities to make assessments as well as opportunities for finding application for the results. For example, in the final lecture in ALPS, each team proposes a service or a product depending on the assigned topic. On such occasions, around 10 entrepreneurs, corporate people and research institute personnel also participate to examine whether the proposals could be put to use in society.

Instruction is assessed by conducting a questionnaire among the attending students during the last lecture of each lecture subject. The assessment of each lecture subject is verified by the instructor in charge and related parties while assessments made by the attending students regarding overall learning offered by the graduate school are shared with all the instructors to identify issues and to enable suitable corrections in lectures conducted the following fiscal year. We are also considering to add a mechanism that would allow five members from industry with experience in developing and operating large-scale complex systems to act as an external evaluation committee and regularly assess graduate school education provided by the SDM program.

RESULT AND FUTURE WORK

Two years have elapsed since the inception of the SDM program and results and assessments made up the graduation in March 2010 will be used to lay the groundwork for future objectives as described below.

Results of Group Learning Involving Talented People

ALPS had teams perform group projects throughout the year and made many students realize the requirements that society placed on them and this became a source of inspiration that helped them acquire new ideas and techniques. As an example, we will introduce an idea created by a team and show the results.

This team, who were assigned the ALPS theme "Sustainable Community," came up with a proposal to convert abandoned schools in the city to create a hydroponics cultivation system that would simultaneously solve the increase in schools closed due to declining birth rates, shortage of people willing to perform farm work and the worsening jobless rate among young people. The strength of this proposal is that it meets consumer needs for fresh, safe and secure vegetables, the demands among young people for work in the city that generates a stable income in addition to building a sustainable business model. Using techniques and procedures ALPS had taught them, the team conceived this proposal by conducting market surveys, handing out questionnaires among stakeholders, holding interviews and building a test plant with a prototype to verify the effectiveness of their proposal. As a result, the team was awarded the top prize in the "student entrepreneur championship," an event organized by Tokyo City and Tokyo Metropolitan Small Business Center. The Nikkan Kogyo Shimbun awarded them the "Campus Venture Grand Prix." Currently, more members have been added to the team and they are now examining the possibilities for starting this venture in earnest and are conducting a survey of local communities and related corporations. This example shows how SDM education makes it possible to identify a social requirement and provide the capability to produce a design that takes into account all aspects of the life cycle of the system from its conception, to operation and through to disposal.

In addition to ALPS, this achievement also verified the validity of other lectures, group learning and group debates stressed in the SDM concept. The students with their diverse backgrounds were thus able to come to grips with their backgrounds. By debating they were able to share know-how absorbed in lectures and collaborated through frequent training to address the problem managing in the process to reap high educational results.

Learning By Combining Multiple Disciplines

Collaboration among instructors makes possible lectures that transcend single discipline frameworks in multiple forms. We received feedback from students on this. The following is an example. An instructor with expertise in social science was the center of a research group, who had been assigned the topic "Call triage emergency system." This led another instructor with a background in technical subjects to collaborate by holding a lecture entitled "System simulation techniques" and went on to design and verify a system for simulation technique. This system was analyzed from a technical and social science standpoint to make improvements and verify it. For example, when an ideal technical solution is implemented, legal constraints become a problem and the current legal restraints may contain technical limitations that can be solved. Thus we are able to hold a technical debate in greater detail. Collaboration with disciplines that have little to do with the problem at hand can result in effective learning. "System life theory" was also used to teach system design from the environmental adaption of organisms and meant that we were able to hold lectures and exercises on a design theory that took into account unforeseeable events that had not been amenable to previous systems engineering techniques. This is an example indicating that system design and management transcends systems engineering and is suitable for social and human system design.

Student Assessment

An attitude survey was conducted targeting the 36 two-year students that joined the Master's course during the spring term of 2008 to determine what capabilities they thought had improved after 1 year of SDM research and to what degree it had improved, what experiences they have had that they are satisfied with and to what degree. To enable comparison of survey results, an attitude survey was also conducted on the 23 students in the 2nd year of the Master's course in Mechanical Engineering at Keio University Science and Technology Graduate School. The attitude survey allowed a 6-scale grading. A sample test was conducted on the survey results for each item of both courses. The level of significance was found to be 1% and Figure 7 shows there was some difference in the level of superiority. The top graph indicates the average values and standard deviation of the survey results obtained from the SDM research students while the lower graph indicates the corresponding values for the survey results obtained from the Science and Technical students.

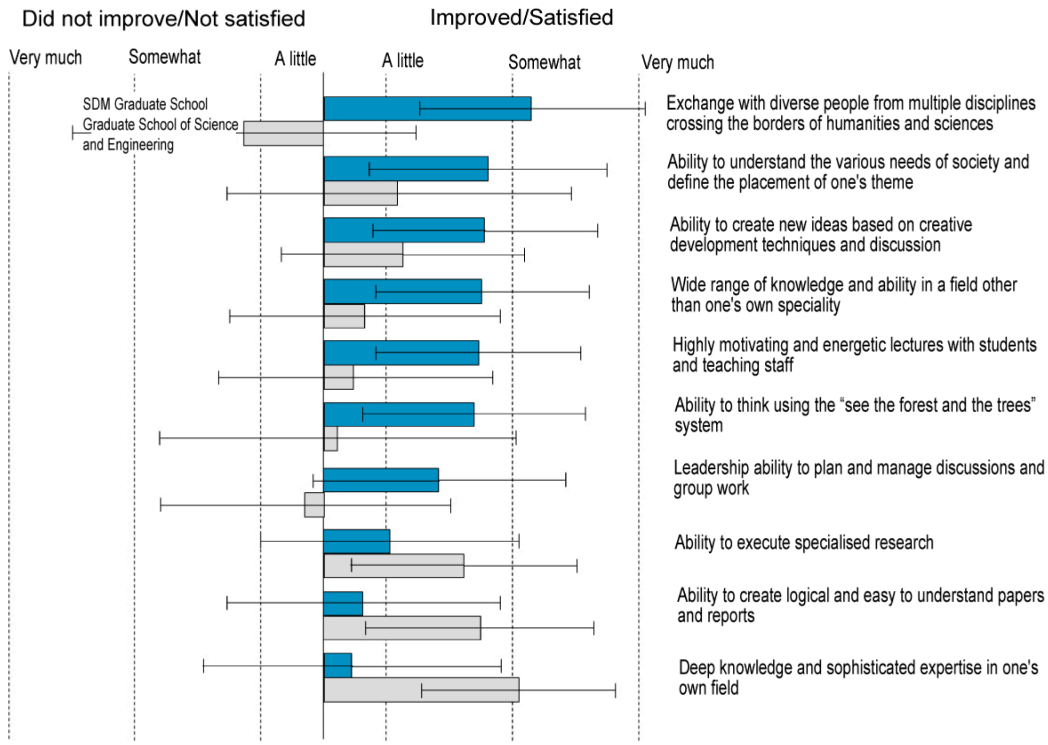

Figure 7. Comparison of Students' Opinions of SDM and Science and Technology

These results indicated that the educational and research curriculum for the SDM program at least in terms of the self-assessment made by the students themselves provide a level of education and research that meets the requirements of Industry regarding science and technology universities and graduate schools listed in Table 1. The students in the SDM program gave themselves a poor mark on "writing ability to prepare a logical and easy to understand thesis," a problem that will have to be taken corrected later on. Since the attitude survey was only targeted at students who had just started their 2nd year, the low mark in writing for the SDM students may have been because the first year had primarily consisted of field work and other activities. There are plans for lectures for improving communication skills. ALPS provides document preparation skills in the form of team writing of English reports and later thesis writing will provide Japanese writing skills.

Since learning that provides deep knowledge and advanced expertise is essential, we are considering to create a curriculum that improves such capacities equally. As the expertise varies widely between students, great discrepancies in the capacities and know-how between students may be a problem with some lecture subjects. So far lectures have been aimed at the highly capable and knowledgeable students and the imbalance could be corrected by providing complementary lectures.

External Evaluation

At the end of fiscal 2008, we asked an external evaluation committee of five people to make an external evaluation of the SDM program after one year had elapsed. The results gave us high marks for the new learning we provide, but a number of areas where improvement was necessary were also pointed out. Results of the SDM program after one year, closer collaboration with industry is required, there should be a proper program for training lecture mentors to give them the necessary independence, ability to see the big picture but also be able to see the details “ability to see the wood and the trees”, strict adherence to the education and research concept of the SDM program, etc.

Measures have already been taken to make the indicated improvements. Regarding close collaboration with industry, for example, we are examining and making adjustments to provide a mechanism for greater collaboration with industry with regard to ALPS depending on team proposals. We are also thinking of aligning the problems presented in the lectures with the problems encountered in industry and proposals created in the course of a lecture will be fed back to the corporation providing the problem.

CONCLUSION

The SDM program established with objective of fostering human resources capable of leading the building and operation of the large-scale complex systems used in technical systems and social systems graduated its first students in March 2010. The evaluations submitted by the students and our external evaluation committee have indicated that the course has been successful in making them acquire the capabilities and know-how necessary for handling the large-scale complex systems that we set as a goal in establishing the course. The educational curriculum, which emphasizes group learning and group debates among our diverse human resources systematically clarifies social requirements, enables creation of ideas, and the results they have produced in master’s course work prove that they possesses reasoning and methodology to form concrete ideas. The expansion of the educational curriculum to enhance the advanced expertise of the students and the great differences between area of specialization of the students have increased the capability and know-how gap between them. Plans are being made to improve our educational curriculum and further strengthen our collaboration with society, industry, related educational institutions, universities and graduate schools. We will conduct follow-up surveys on graduating students to trace their course in society and industry. We think that more detailed assessment and verification of results and problems in the SDM course at the graduate school will allow us to further enhance our graduate school education.

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