# Outcome Design and Assessment for Interdisciplinary Education

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## Abstract

College of Systems Engineering and Science, Shibaura Institute of Technology was founded in 1991. Each department in the college has delivered specific major education and shared common interdisciplinary education of systems engineering. The knowledge and skills in systems engineering including project management are necessary for engineers who solve technical as well as social and interdisciplinary problems. We define our interdisciplinary education by emphasizing systems approach with interdisciplinary communication and teamwork skill for solving real problems in society. The main part of interdisciplinary education consists of three lectures and three Project-Based Learning (PBL) for mixed students of five departments. In this paper, learning outcomes design, course design, execution, and assessment are described.

## 1. Introduction

College of Systems Engineering and Science, Shibaura Institute of Technology was founded with three engineering departments in 1991. Each department has delivered specific major education and shared common interdisciplinary education of systems engineering (fig.1) [1] [2]. The knowledge and skills in systems engineering [3] including project management (fig.2) are necessary for engineers who are engaged in planning, designing and analyzing systems and process. In 2008 and 2009, two departments of bio-science and mathematical science were initiated and now the college holds three engineering and two science departments. In this occasion, we are redefining the learning outcomes and building quality assurance system for the interdisciplinary education.

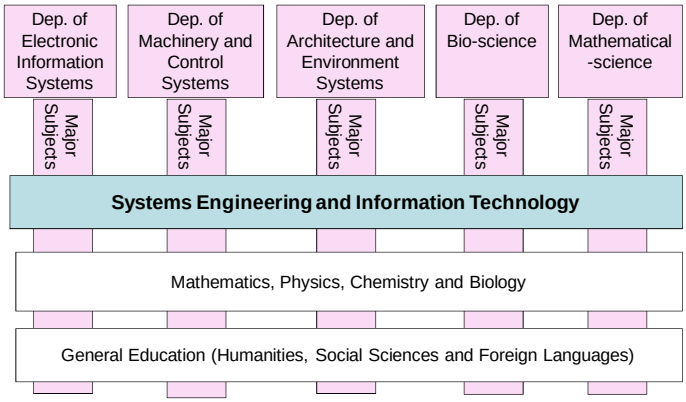



Figure 1: Departments and Courses, College of Systems Engineering and Science.

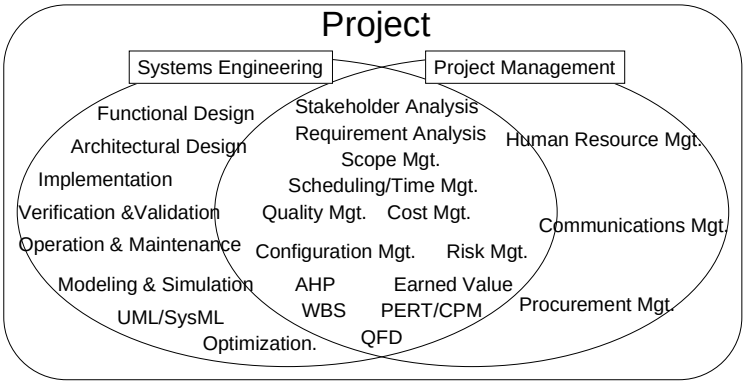



Figure 2: Systems Engineering and Project Management.

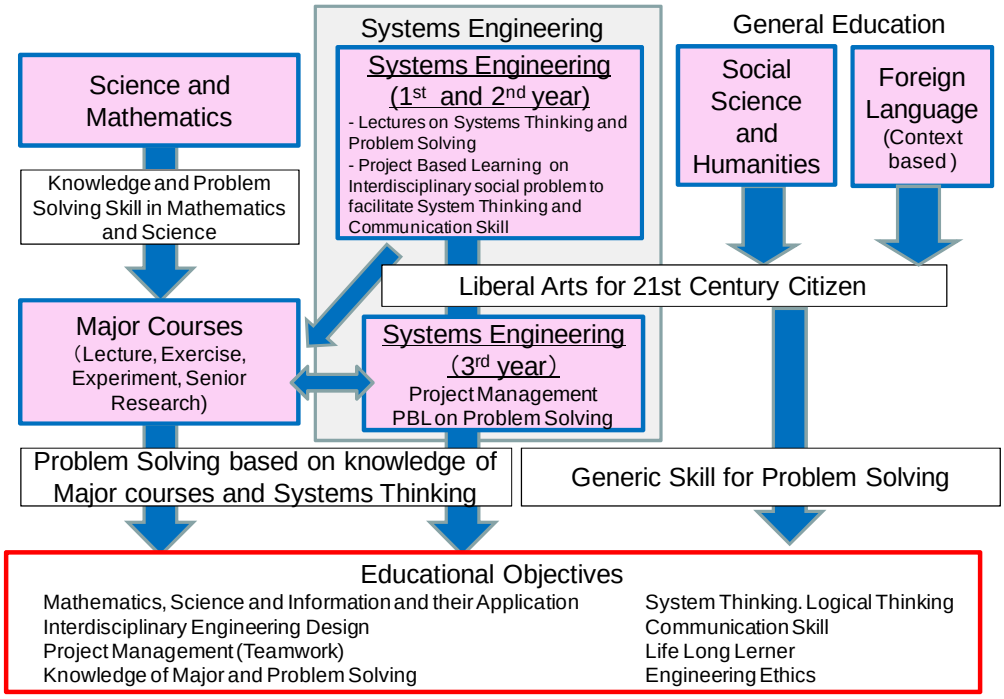



Figure 3: Curriculum Structure of College of Systems Engineering and Science

Figure 3 shows curriculum structure of the college which consists of general education, science and mathematics, systems engineering, and major courses. General education and systems engineering are shared by 5 departments. Major courses are individually delivered by 5 departments.

## 2. Learning Outcomes of Systems Engineering Education

Systems engineering has two aspects: one is mathematical approach to solve and optimize well-defined technical problems, and the other is systems approach to define and formulate problem, and synthesize system. We defined our interdisciplinary education by emphasizing systems approach with interdisciplinary communication and teamwork skill for solving real problems in society.

Learning outcomes of interdisciplinary education have been defined according to educational objectives (table 1). The learning outcomes are mapped to 3 lectures and 3 exercises in undergraduate education.

Table 1: Learning Outcomes of Systems Engineering Education

| Learning Outcomes | Competency | Courses | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Systems Engineering A | Systems Engineering Exercise A | Systems Engineering B | Systems Engineering Exercise B | Systems Engineering C | Systems Engineering Exercise C | Systems Engineering Exercise (graduate course) |
| "System Thinking" - Solve interdisciplinary problem by understanding systems engineering process | 1. Understand systems engineering process and apply it to solve interdisciplinary problem | ++ | ++ | | | | + | + |
| | 2. Recognize and analyze problem, and design and evaluate solution | ++ | ++ | | | | ++ | ++ |
| "System Methodology" - Apply systems engineering methodologies to solve interdisciplinary problem under constrains | 1. Understand system engineering methodologies and apply them to model, optimize, and determine system | + | | ++ | ++ | | | |
| | 2. Understand statics and apply it to simulate system by Monte Carlo method | | | ++ | ++ | | | |
| "System Management" - Manage human resource, knowledge and technology to plan and execute project | 1. Understand project management process and apply it to project | + | | | | ++ | + | + |
| | 2. Develop project plan, execute project, and manage human resource, knowledge and technology to satisfy scope, cost and time constrains. | | | | | | ++ | ++ |
| Work in interdisciplinary team | 1. Communicate multidisciplinary | | ++ | | ++ | | ++ | ++ |
| | 2. Teamwork | | ++ | | ++ | | ++ | ++ |
| Communicate logically in written and orally | 1. Write document logically | | ++ | | ++ | | ++ | ++ |
| | 2. Oral presentation | | ++ | | ++ | | ++ | ++ |
| Engineering Design - Design system and process which satisfies needs and constrains | 1. Design system and process which satisfies needs and constrains | | | | | | ++ | ++ |
| | 2. Design and implement system by using methodology and tools | | | | | | + | + |
| | 3. Evaluate and improve system and process to satisfy defined requirement | | | | | | + | + |
| | 4. Document system and process | | | | | | + | + |

Note: ++ strong relation, + relation

**Figure 4 shows systems engineering courses and major courses which are mapped to systems engineering process [3].**

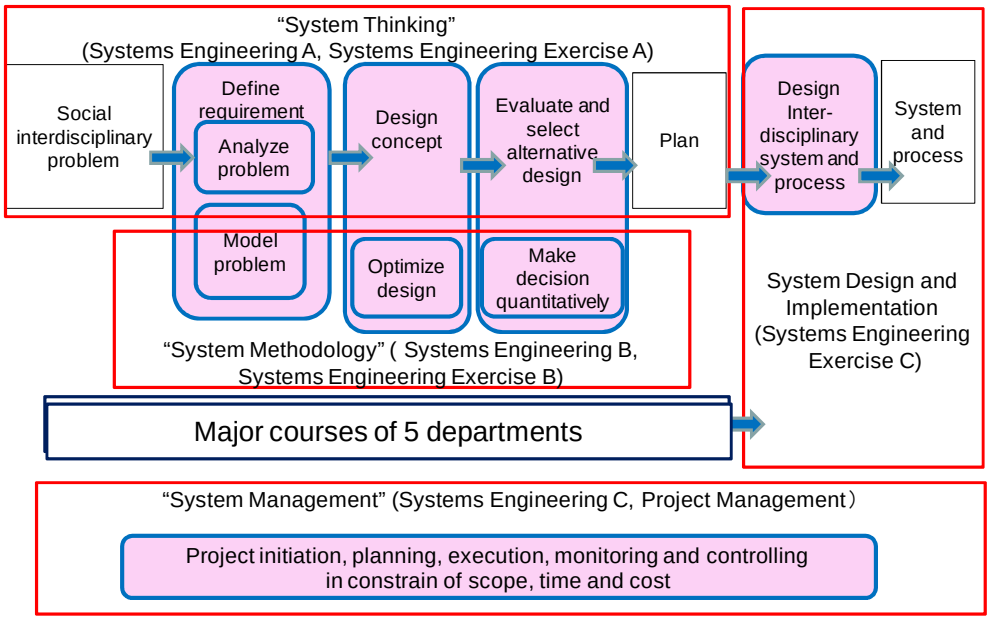



Figure 4: Systems Engineering Courses Mapped to Systems Engineering Process

## 3. Evolutional Project Based Learning of Systems Engineering Education

The main part of interdisciplinary education consists of three lectures and three Project-Based Learning (PBL) for mixed students of five departments. In the curriculum, exercises and lectures are executed alternately and evolutionally in three steps of PBLs (fig. 5); Workshop of System Thinking, systems approach with system life cycle model is delivered in the first step PBL. Mathematical approach to solve and optimize problems is provided in the second step PBL. Finally project management is obtained in the third step PBL. The series of PBL are executed by cooperative efforts of more than 50 faculties from 5 departments. In the education, it is extremely important for faculties to share clear educational objective and learning outcomes.

### 3.1 The First Step of Evolutional Project-Based Learning

Workshop of System-Thinking is placed at the first term of the first school year. It is a project based exercise for the first time after students enter the college. Sixteen faculties from the five departments take charge of the projects. Examples of exercise theme are "creates future," "creates key," "creates toy," and "creates green campus". Presentations of student groups are held at the end of projects. Prizes will be given to the excellent works and presentations.

Systems Engineering Lecture A (System Planning) is arranged at the first term of the second school year. The contents are systems engineering life cycle, brainstorming, problem solving methodology, system modelling, UML (Unified Modelling Language) [4], system evaluation, introduction to project management, and lecture of industrial practitioner.

Systems Engineering Exercise A (PBL: System Planning) is arranged at the first term of the second school year. It is the first project-based exercise after learning systems engineering process. Project themes are provided by the faculties. For the themes, planning, designing, modelling, evaluation, and presentation are executed by mixed student groups from five departments. Twelve faculties take charge of them. "CO2 reduction system for preventing global warming," “Countermeasures for declining birth-rate and aging population”, and “Disaster prevention system" are themes for fiscal years of 2008, 2009, and 2010 respectively.

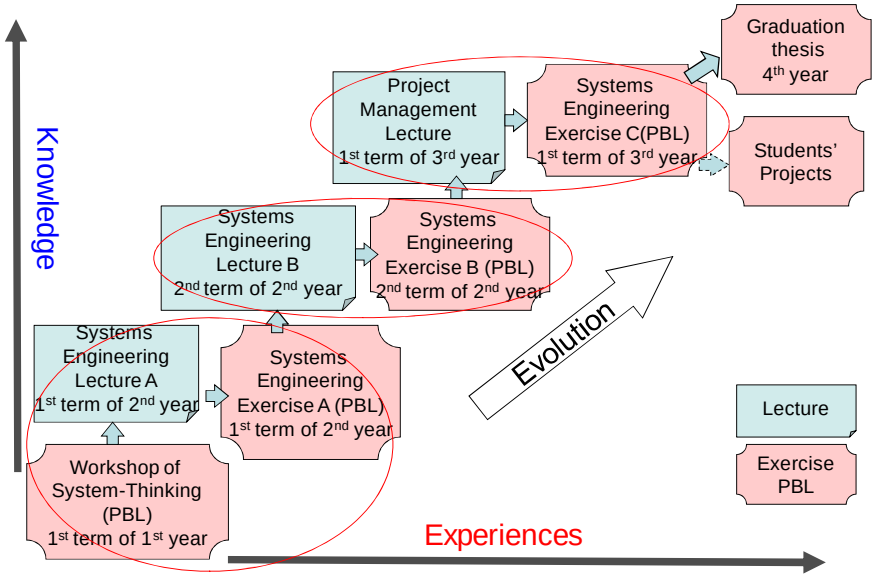



Figure 5: Evolutional Project Based Learning.

3.2 The Second Step of Evolutional Project-Based Learning

Systems Engineering Lecture B (Mathematical Programming) is arranged at the second term of the second school year. The content is decision making theory, probability statistics, scheduling, queuing theory, Monte Carlo method, linear programming, and a special lecture from industry.

Systems Engineering Exercise B (Mathematical Programming) is arranged at the second term of the second school year, and 16 faculties are taking charge of it. The exercise is executed by groups of students from five departments.

3.3 The Third Step of Evolutional Project-Based Learning

The lecture of project management [5] is arranged at the first term of the third school year. It composes of fifteen lectures. The content is as follows:

(1) Introduction to Project Management and Project Management Process.

(2) Project Management Knowledge Area and Project Initiation

(3) Project Scope Management and WBS

(4) Project Time Management

(5)(6) Project Cost Management and EVT (Earned Value Technique) Exercises

(7) Project Quality Management and Project Procurement Management

(8)(9) Project Management Software Tool and Exercise

(10) Project Risk Management

(11) Project Human Resources Management and Project Communications Management

(12) Project Management Case Lecture by Project Manager in Industry

(13)(14) Project Management Planning Exercise

(15) Term Examination

Systems Engineering Exercise C (PBL: Project Management Exercise) is executed concurrently at the first term of the third school year. In this project, students determine their own theme. Student groups make project plans and execute projects. Student's theme in fiscal year 2006 are “Red clay outflow measures project for Ishigaki island,” “Robot and science teaching material development project for the high school students,” and “Architectural experience project (temporary housing in disasters)”. Most students continue to execute the projects by obtaining financial support from the university or support programs.

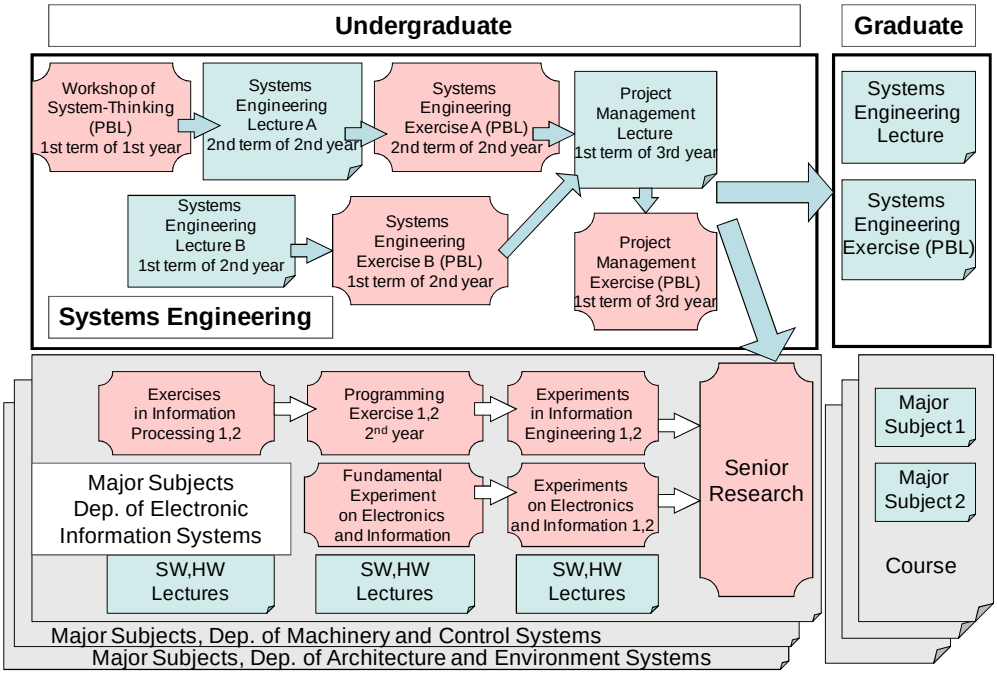
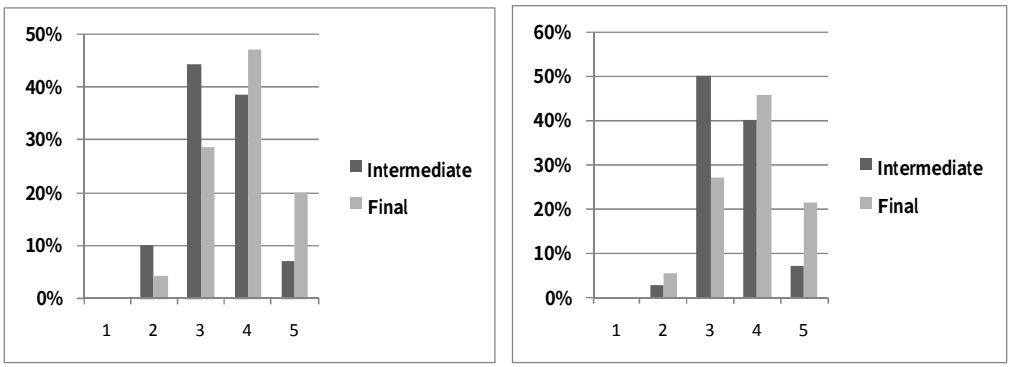



Figure 6: Collaboration of Systems Engineering and Major Courses.

## 4. Assessment of Systems Engineering Education

Rubrics are defined for systems engineering education to show learning objectives clearly to students and assess the outcomes of education. A rubric is a scoring guide that clearly differentiates levels of student performance [6]. Rubrics provide a clear description of proficient students work and serve as guide for helping students achieve and exceed performance standard. The rubrics supply the basis for self-assessment by students and evaluation by faculties. Figure 7 shows an example of results of assessments based on rubrics for “work in interdisciplinary team”. The assessment has been executed both in the middle and the end of courses.




(a) Communicate multidisciplinary (b) Teamwork

Note: 5: excellent, 1: poor

Figure 7: Example of Assessments Based on Rubrics for “Work in interdisciplinary team”

In each project-based learning, faculties from five departments have weekly review meeting to share the goal and status of education and improve continuously education quality with PDCA (Pan, Do, Check, and Act) cycle.

## 5. Conclusion

We define our interdisciplinary education by emphasizing systems approach with interdisciplinary communication and teamwork skill for solving real problems in society. The main part of interdisciplinary education consists of three lectures and three Project-Based Learning (PBL) for mixed students of five departments. Learning outcomes design, course design, execution, and assessment were described.

As the result of the education:

(1) Students understood learning outcomes more clearly and recognized their improvement of ability by using rubrics.

(2) Students perceived the importance of interdisciplinary communication and teamwork and made effort to achieve them.

(3) Faculties from 5 departments share common educational objectives and assess students' performance more accurately by using rubrics. Fluctuations in the evaluation have been reduced.

We are planning to improve rubrics continuously based on feedback from students. We will design electronic learning portfolio system for students to know their present status and improvement of their competencies.

## References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