LARGE SCALE PROJECT BASED LEARNING IN SERVICE DESIGN AND ENGINEERING (SDE) MASTERS PROGRAM

Mika Helenius
Aalto University / School of Science and Technology
Department of Computer Science and Engineering (CSE)

ABSTRACT

In early 2008 Aalto University / School of Science and Technology (known as Helsinki University of Technology), initiated an internal development process aiming for an international engineering's master's program in the field of service science, a new evolving cross discipline. The driving forces were the need to integrate and build closer relationships between different merging schools, innovate in program offering, meet the European Union Bologna 3 + 2 + 3 education requirements, teach pre-doctoral research skills at the master's level, and serve the contemporary industries' emerging needs in the engineering of service systems and user driven innovation. During the development process, new ideas were introduced from systems thinking and future engineering perspectives. Industry executive's insight where used in the development process together with learning outcomes of the CDIO syllabus. As a result of this process, a new International Master's Program in Service Design and Engineering (SDE) started at Aalto University in the fall of 2009. The program is founded in the computer science and engineering (CSE) research domain, focuses on engineering systems with software and digital systems. Program covers thematic topics in service systems, management, design, innovation, technology, and entrepreneurship. The SDE is designed to meet the new complex digital service "engineering," "design," and "social" systems intersection and integration challenges addressed by the industry and the research community. The core of the SDE program is research-to-operation oriented courses that integrate the learning outcomes of the other courses in the curriculum. This paper presents the development process, core content of the programme and experience from the process from the program director point of view. Paper also presents how the CDIO framework is used for benchmarking and as an assessment framework for a new multidisciplinary master level program. Paper presents new ideas for discussion to extend the CDIO framework to better meet master's level education requirements.

KEYWORDS

CDIO, SSMED, service systems, service science, service design, service engineering, education management, program management, future of engineering

1. INTRODUCTION

"*Today we are witnessing an extraordinary transition of our economy into the system-of-systems"* by Garviel Salvendy, April 2010

Services have acted as a means to achieve competitive advantages for a product firm expanding its portfolio into a professional service business and as a means to increase value perception through customer-oriented service by the service dominant logic (SDL) [2]. Today, an increasing number of companies are either considering or are already evaluating expansion into holistic services [3] and integrated value added service systems (iVASS) [4], if not already making their way through the transition.

The evolution of the service science paradigm has come about as a central integrating research topic in the merger of three established universities in Finland: the Helsinki University of Technology (TKK), the Helsinki School of Economics (HSE), and the University of Art and Design in Helsinki (UIAH) have been combined into a research-focused academic institution, Aalto University. This merger has generated a need to facilitate the integration and change processes, and a need to communicate the opportunities and outcomes of the innovative combination of the art, design, business, and technology in education and research. One of the new faculty collaboration arenas has been service science through Aalto Service Factory (ASF).

The new university strategy clearly states that the Aalto is a research university. It shall have fewer undergraduate and more graduate students and post-doctoral researchers in the future. This ratio is expected to be far higher than in the other universities in Finland. Master's and doctoral education is going to be one of the major components of the new Aalto innovation strategy. This will not conflict with the university's role of educating knowledgeable and skilled next generation engineers for industry, research community and society.

Simultaneously, the EU Commission's strategic organization for excellence in higher education, research, and innovative businesses—the European Institute of Innovation Technology (EIT)—selected Aalto University as one of the co-location's ICT Knowledge and Innovation Communities (KIC) Labs. This lab is going act as a link for SDE to the other European research and education centers, and Otaniemi science hub.

The innovation in academic research and education was one of the key objectives in the early stages of the Aalto process for the EIT ICT Labs. Aalto and EIT have emphasized the importance of software and digital service in their strategies. The new design and engineering oriented curriculum was initiated by the head of the CSE department in the early 2008 to match future objectives as part of the bigger plan. The new SDE curriculum became part of the Aalto offer for the EIT ICT KIC Labs Education area.

The international service science master's program, SDE, started at Aalto University's School of Science and Technology in the fall of 2009. The mission of the program is to educate professionals for the software and digital service industry through a global, international, and multidisciplinary program, with high societal impact in mind. This paper describes how the CDIO educational framework and syllabus [5] have been applied. The paper presents a combined constructionist learning model using situated context [6], community [7], project and problem based learning [8] and cognition approaches in the development of the SDE program as a whole.

2. THE PROGRAM DEVELOPMENT PROCESS

The SDE program was originally developed during 2008 as a traditional new international computer science and engineering curriculum by CSE faculty members, with some focus on design and entrepreneurship. The primary objective of this process was to use as many existing courses as possible or to renew the old courses. After a careful review and analysis, the selected courses were translated into English and modified to meet new international SDE curriculum requirements. This process included 6 to 10 faculty members, such as professors, post docs, and senior researchers from various CSE disciplines, who presented the following fields:

- usability and user interfaces
- software architectures
- software engineering
- enterprise systems
- mobile computing
- requirements engineering
- computer science
- embedded systems
- information and technology law

The result of this iterative process was the SDE programs draft version 1.0. This early version was given as the basis for the program director's development and coordination work late January 2009. This early version of the SDE program consisted of the new Master Studio and the old courses from the curriculum. The learning objective of the new Master Studio was to analyze what kinds of services exist and are available on the Web, and how to discover, build, use, and access them. Problem-based learning was selected as the way to deliver courses.

The experienced industry executive, who was originally recruited as a doctoral student, took full-time responsibility for the program in mid-February, despite the part-time compensation, since other resources were not available. The program director's long industry experience, expert knowledge and knowledge sharing motivation on the cross-disciplinary education programs made it easy to analyze and benchmark the program with other similar programs. This early version of SDE as a whole was thoroughly revised to meet the future engineering education requirements, Aalto high quality education outlines and coming EIT KIC ICT Labs expectations. This phase did not include any formal analysis of curriculum using existing syllabus frameworks (etc. CDIO) or accredited engineering program models (etc. ABET). The identified weak points of the initial version of the program can be summarized:

- community building
- industry relevance
- design and foresight
- interpersonal skills
- communication skills
- research publication skills
- inflexibility in curriculum
- new research area opportunities
- international joint program co-operation

2. INTERNATIONAL SDE MASTER'S PROGRAM

The Aalto SDE master's program focuses on high quality education, with an emphasis on a complex digital system of systems engineering research. The program integrates the digital service business, design, entrepreneurship and venture development, and engineering education with international and cross-talented students. The intensive SDE program strongly emphasizes foresight, service development, business ventures, and technology management. All students will be engaged in a real-life research-to-venture project. The full-time SDE program provides majoring in the following research oriented specialization tracks:

- Service Technology and Engineering
- Service Innovation and Venturing
- User Driven Design and Usability
- Enterprise Systems and Management

A successful Aalto master's program addresses the following education requirements [9]:

- The scientific research environment is expected to be committed, collaborative, and interdisciplinary.
- Course, curriculum, and degree requirements are aligned with the learning objectives and strategy.
- The program works as an integration platform which synthesizes and incorporates existing lecture elements into new courses.
- The program operates as a sourcing center, acquiring different education and learning services from faculty.
- It will be institutionally committed to faculty and management.
- There will be an annual program self-evaluation with established international framework and guidelines.

The SDE program aims at educating students into a solid knowledge in "engineering systems" and "service systems" in the field of service design and engineering. The program starts with service foundations, through an introduction to the service science course which is organized in co-operation with professors from all different schools from Aalto. Parallel to this, the first two periods in the first fall are focusing on context building and basic technical foundations. The industrial Insight & Innovation project course starts in the middle of the fall (see Figure 1) and run parallel with the Master Studio. This project course focuses first on foresight, scenario building, open innovation, living labs, and engineering systems. The Master studio is focusing on service engineering using problem based learning (PBL) both the consumer and enterprise aspects of service lifecycles are covered. The Master Studio is followed by intensive and short Service Camp course taking place in the end of the first year before summer internships.

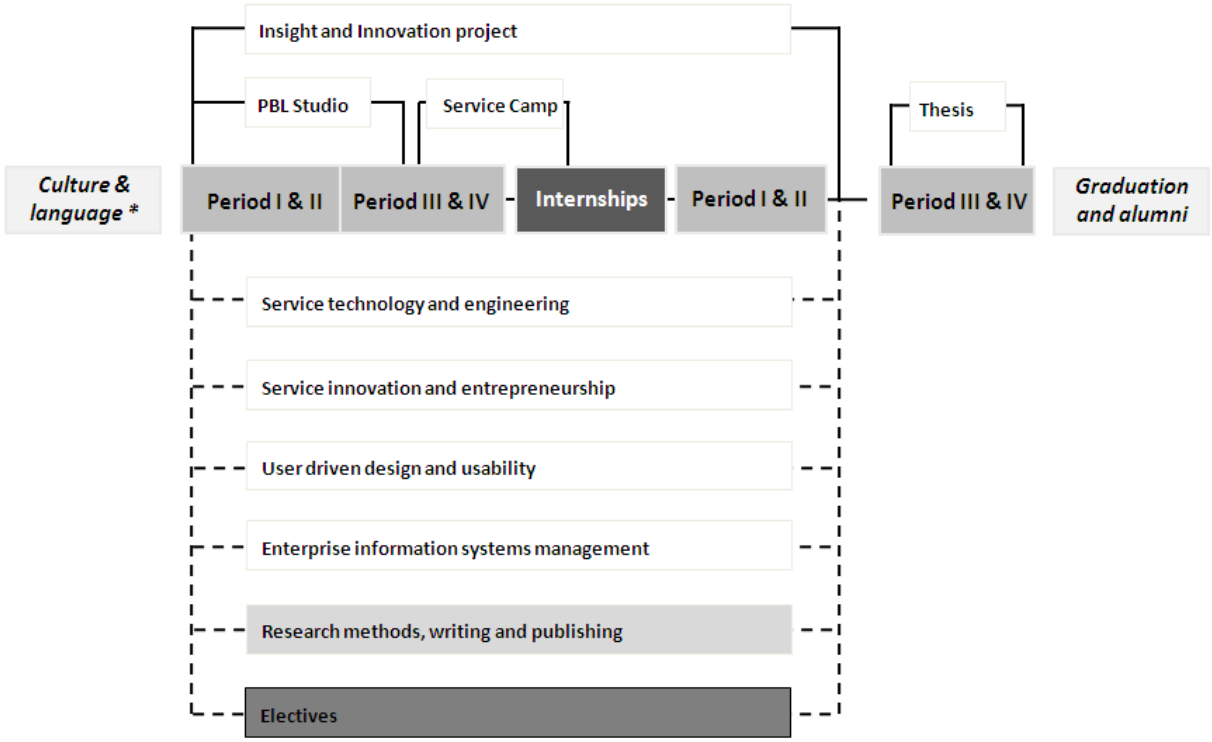

Figure 1. Aligned Aalto SDE curriculum

The program structure has primarily been developed based on the good experiences within the Aalto University from the International Design Business Management (IDBM) program and the Product Development Project (PDP) courses and Ship Project (SP) course and in the later refactoring with the CDIO framework using both the standard and the syllabus [5]. The IDBM, PDP, and SP have used a CDIO like approach since the early 1990s. The CDIO an engineering education initiative was introduced to author as extra curriculum reading material in the diploma in university teacher's education provided by the teaching and learning development unit at Aalto early fall 2009.

The Aalto SDE program has, from the very beginning, been active integrator of courses and modules from different schools to facilitate and increase interaction between different disciplines, campuses, and schools during the merger process. One of the aims is to make cross disciplinary and entrepreneurship education embedded a part of the engineering and science curriculum rather than a separate topic with no link to the substance curriculum and no connection actual venturing reality in industry.

2.1 Industrial insight industry partnerships model

The SDE program's Insight and Innovation partnership model is based on industry partners' need to innovate, cope with the dynamic change, understand complexity, recruit new talent through co-operation, educate potential new employees before employment, synthesize potential ideas from different disciplines, and become more competitive on the global market. The SDE program has addressed these needs in the form of long Insight and Innovation research-to-venture projects course.

The Insight and Innovation projects are funded by the industrial partner grants amounting from 30 up to 200 k€ per student research project. This funding will typically covers the following:

- one high level and open research topic
- project of 200 – 600 man days in scope
- one international team of 4 – 8 students
- program director as a team coach
- program director as a partner mentor
- one enterprise executive as a mentor
- one teaching assistant as a mentor for team
- full 8 - 10 week internships for the whole team
- conceiving international field study
- briefings of selected topics by students
- right to publish the "research process" findings

The Insight and Innovation project is neither isolated nor a stand-alone project. One of the key prerequisites is that the industry partner shall have appropriate resources and an own internal project or development activity starting about the same time as the student team. The Insight and Innovation offer the industrial partner a unique education opportunity to open eyes for innovation, free blocked or biased minds, cheer new concepts and approaches, improve the research and development process with external research organizations, and to change the way people inside organizations approach outside knowledge opportunities. These two projects have to interact (see Figure 2). They are set to challenge and compete with each other in such a way that they also share and synchronize all the findings and documentation during the course of the project. The partners have remarked this as a "true open innovation concept," and a customer's reference group member remarked, "You are doing research on a really hot topic currently in our industry."

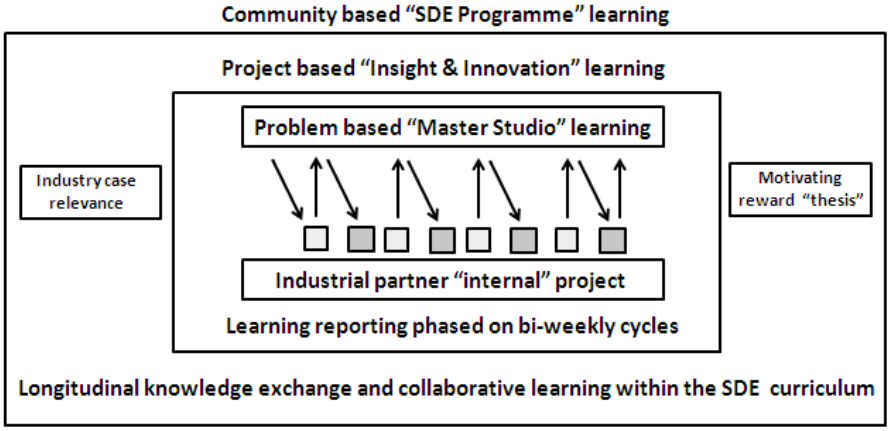

Figure 2. Aalto SDE Insight research project model

2.2 Evolutionary master's program in Aalto

The SDE program is in many ways an evolutionary program in the context of Finnish research university education. The program has a project course that is 2 to 4 times longer than in any other program. SDE program funding comes mainly from outside of the university. The program provides research and industry internships, housing grants, and international industry case relevant field trip opportunities for full time honour students. Program is also using code of

conduct agreements to align student work and emphasise the importance of full time studies, community building and good study progress. The programs development is currently focusing on international partner networks with the EU EIT Labs research and education network, international universities and multinational research organizations.

3. FOUNDATIONA AND STRUCTURE OF SDE

The higher education in Aalto University is based on scientific research or artistic activity and professional practices. The international Master of Science degree program at Aalto University School of Science and Technology shall provide the following learning outcomes to the graduating students [9]:

- good overall knowledge of the major subject of the degree program;
- the knowledge and skills needed to apply scientific knowledge and scientific methods, or
- the knowledge and skills needed for independent and demanding artistic work and;
- capability for lifelong, flexible learning;
- the knowledge and skills to understand the problems of his or her own field, from the point of view of the user, of technical and social organizations, and of the environment;
- the knowledge and skills to operate as an expert and developer of the field in working life;
- good language and communication skills;
- the knowledge and skills needed for scientific or artistic postgraduate education.

The program has used the following criteria for admissions. The students are required to complete undergraduate degrees in computer science, information management, media technology, industrial engineering, systems engineering, business administration, economics, information sciences, or social sciences before official acceptance to SDE programme. The applications are assessed on the basis of following criteria:

1. proficiency in English (TOEFL/IELTS/Cambridge)
2. recognition and quality of the home institution
3. language proficiency
4. content of degree(s)
5. study success
6. motivation and full-time commitment to the program as indicated in the motivation letter
7. recommendations from home faculty and employee
8. other relevant studies
9. relevant work experience or other relevant activity

The SDE Master of Science degree (M.Sc.) studies consist of minimum of 120 ECTS (European Credit Transfer and Accumulation System). The SDE is organized around six modules (see Figure 3): three modules are in the subject area of the studies, each of them 20 ECTS for a total of 60 ECTS; one elective subject area module is 20 ECTS; one research methodological principles module is 10 ECTS; and one is reserved for the individual master's thesis writing project for 30 ECTS. From the three subject area modules at least one shall be an advanced module with a minimum of 20 ECTS in one of the major subjects of the student's own degree program, and of which only one can be a basic module, minimum of 20 ECTS [9].

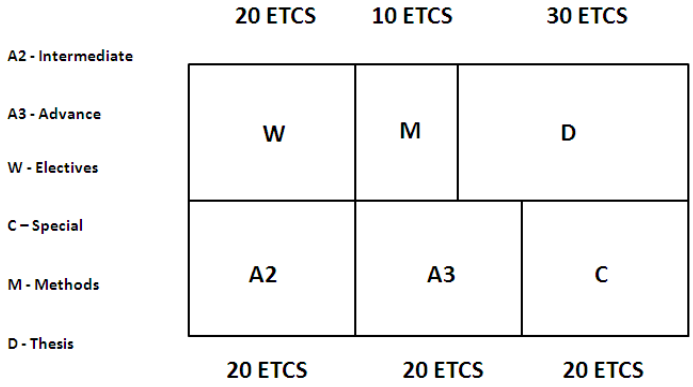

Figure 3. Structure of Aalto School of Science and Technology master's studies

The general subject area (A2) is an introduction to services from a software and digital service perspective; the module provides the foundation for innovative service design and engineering from the engineering systems and service science perspectives. The service business and innovation course introduces the business concepts and processes of services and enterprise level service management and enterprise wide IT governance. These will be illustrated by actual cases from the industry and the public sector. The systems and architecture courses provide a more comprehensive and structured view on issues related to service design, engineering, and complex information systems.

The advanced module A3 is organized in four tracks for which students are able to apply after completing the first period courses:

- Service Technology and Engineering
- Service Innovation and Venturing
- User Driven Design and Usability
- Enterprise Systems and Management

The "Service Technology and Engineering" track provides insights into specific areas related to the implementation of software intensive services with more traditional courses such service-oriented architecture and software engineering and architectures, distributed systems, information and intelligence, advance requirements engineering and business process design and implementation. These include implementation and evaluation of architectures and integration technologies.

The "Service Innovation and Venturing" track concentrates on open innovation, customer-centric development, software business, entrepreneurship, user-generated services, ambiguous and complex requirements, and digital service ecosystems, with somewhat traditional courses such requirements engineering, management of a software venture, methods for user-centered product development, advanced course in software business and strategic digital service innovations.

The "User Driven Design and Usability" track is organized in cooperation with the School of Arts and Design and the Strategic Usability Research Group a joint project between Aalto and

Helsinki University. The track covers courses on methods for user-centered product development, storytelling 1, strategic user-centered design, interface prototyping and systems of representation. The strategic design, experience and usability innovations have been identified as a vital capability in the innovation process.

The "Enterprise Systems and Management" track is focusing on strategic enterprise information systems management (ISM). The track focuses on contemporary ISM management and leadership issues covering also technical topic topical issues related to business system specification, requirements engineering (RE) and management, enterprise architecture (EA) and federal architecture (FA) concepts, enterprise information systems (EIS), systems integration (SI), service oriented architecture (SOA) and business informatics and intelligence (BI).

The high level SDE program learning objectives can be summarized as follows:

- understand general principles and concepts behind computer, information and software disciplines;
- develop the cross-disciplinary service science comprehension and skills necessary to synthesis and evaluate the approaches of other disciplines;
- learn to analyze large and complex service systems and evaluate potential cross-disciplinary solutions;
- learn how other disciplines approach, position, and study problems and how to cooperate and innovate using such approaches sets;
- develop an understanding of the design, systems, and problem-solving paradigms used by various disciplines;
- learn the language, culture, technology, literature, methodological, theoretical and unique means of expression used by other disciplines;
- learn the skills needed to work effectively in an international interdisciplinary research team in both academic and industry contexts.

3.1 Cross-disciplinary and international intake

The SDE program is both cross disciplinary and international. The student intake has been based on high academic credits, experience, and motivation to ensure success in cross cultural teams. Team members are often working for the first time with several nationalities at one time, without a common mother tongue and cultural context.

The SDE program integrates:

- several different nationalities, cultures and languages,
- four different baccalaureate disciplines,
- industrial and research experience,
- different value perceptions,
- personal wealth and well being, and
- diversity in learning maturity and capabilities.

The SDE student intake provides a unique opportunity for cross-cultural learning and global project work.

3.2 Technical knowledge and reasoning in the SDE

The SDE program is a cross-disciplinary master's program aiming for the higher levels in the learning outcomes within design, engineering and systems knowledge and reasoning. The CDIO's scientific, core and advanced engineering knowledge domains are in this case more applied and research-for-use oriented than are pure math, physics, chemistry, or biology. The cross disciplinary knowledge and reasoning foundation in SDE can be seen as a combination of:

- information systems
- computer systems
- systems engineering
- software engineering
- quality management
- operations management
- relationship marketing
- social and organizational knowledge

The traditional engineering curriculums address the lower levels of Boom's [10] taxonomy (knowledge, comprehension, and application) while a holistic and graduate curriculums, such as the SDE should approach the learning from the higher levels (analysis, synthesis, and evaluation). One of the challenges observed during the development process was that the research-oriented senior faculty member's narrow knowledge focus, limited multidisciplinary understanding, and lack of personal interest for the wider program content and higher level learning outcomes. Also the importance of knowledge sharing, social networking, status building and leadership skills in curriculum were distinct limitations when compared to detailed facts and subject matters. This might be one of the reasons why engineering and science has challenges to change, advance, and re-innovate itself internally. The role of unbiased views and outside thinking, such as the expertise of industrial leaders or stakeholder group, could be valuable when developing curriculums, syllabuses, program management, teaching, and educational aspects in higher education.

3.3 Multi-causality and systems thinking within SDE

The service science as a new abstract and multi-causal evolving phenomenon has been approached very differently, depending on the author, research area, thematic interest, institution or philosophy of technology. In the SDE, the service science curriculum covers the higher and more abstract levels of service value systems (SVS) [4], where all aspects of value composition are equally important to enable synthesis on different thematic view, research interests, stakeholder, industry, and life-cycle aspects.

The service value system approach consists of an overall framework that defines the core value creation process (VCP) and value process orchestration (VPO). The SVS can be divided into three main service value components (SVC), which are service networks and ecosystems (SE), service integration and composition (SC), and service design and engagement (SD). The SDE curriculum and research topics should be able address the SVS and its components, along with their connecting interfaces.

The traditional learning methods are not able to solve the multi-causality and complexity within the evolving cross-disciplinary knowledge and reasoning in service science. Our goal is, therefore, to compose a holistic and integrated program with the learning process that combines several constructionist learning levels and methods, and connect these to the regular scientific

engineering curriculum and to practical industrial projects (see Figure 4) to meet masters level graduate education requirements and student expectations.

The integrated learning model is built from four concrete components: problem-based learning, project-based learning, conceptual learning, contextual learning, and community-based knowledge building. Key faculty members have experience using this kind of learning environments, which help to integrate other faculty members and expertise to curriculum.

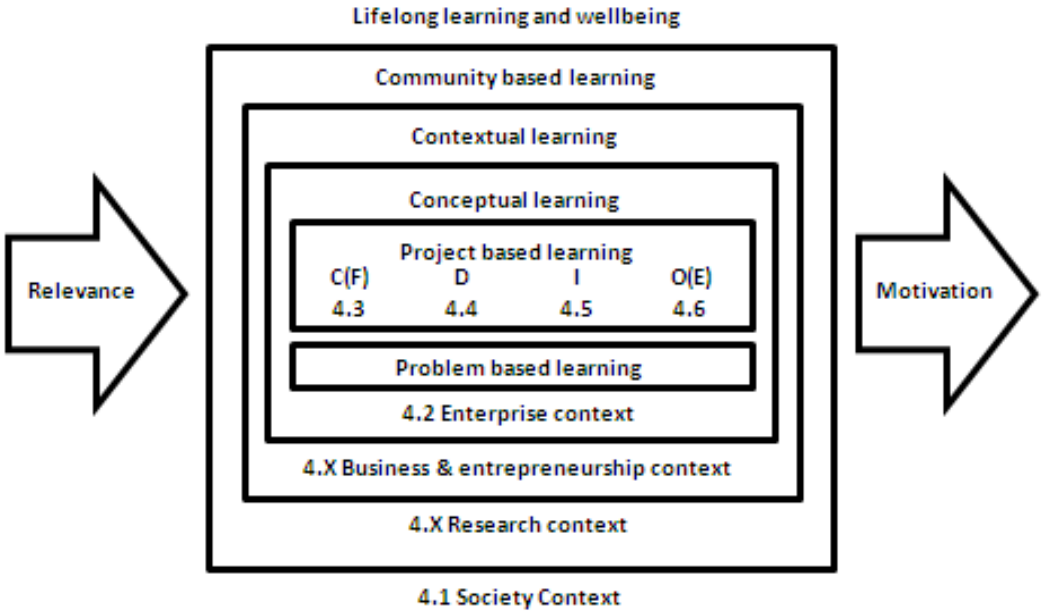

Figure 4. Mapping Aalto SDE learning to CDIO

This approach is both rigor, when pursuing to evolving service science domain, and relevant when, operating in the professional and business relevant domain.

4. CURRICULUM AS INTEGRATION PLATFORM

Close integration of the core courses is essential when aiming for high learning outcomes and good student feedback. SDE program's academic group used several months to iterate the right combinations of courses.

The following courses constitute the core of the new subject area in the program: T-86.5415 Digital Service Insight and Innovation I (2-8 ECTS), T-86.5416 Digital Service Insight and Innovation II (2-8 ECTS), T-106.5260 Master's Studio in Service Design and Engineering (10 ECTS), T-106.5750 Aalto Service Camp (5 ECTS), T-86.5310 ICT Enabled Service Business and Innovation (4 ECTS), T-86.5200 Service research seminar (4 – 10 ECTS), and an optional T-86.5751 Strategic Digital Service Innovations (5 ECTS).

T-86.5310 is an SDE contemporary foundation and topic course focuses on the transition toward a service-based economy and the role of ICT and software enabler for scalable services in this process. The basic concepts of services are covered from operations and marketing

perspectives with joint lectures from different schools and institutions around course topics. business school and industrial engineering. Students are introduced to the concept of service innovation and the enabling ICT-based approaches and tools with industrial expert lectures and visits.

T-86.5415 and T-86.5416, the so-called “Insight & Innovation” courses, focuses on large and abstract research topics and to the challenging industrial project. The learning objective of this course is that after completing it, students shall have a good understanding of complex engineering systems from a contemporary business development point of view. The course covers some lecture topics such as future research, innovation theories, and the relation of service science to basic research and engineering systems. The course also operates as the platform for industrial project coordination and reporting.

T-86.5200, the so-called “Service systems research” seminar, is a first-year research foundation course focusing on the scientific writing process, research collaboration, paper analysis, publication process, identifying the key research findings, service ontology and information visualization etc. mind maps and semantic networks, writing of short papers in topics related to the T-86.5751, T-86.5415, and T-86.5416 courses. The course focuses on knowledge sharing and collaborative research writing using popular journal templates, typical conference time deadlines, citation management and bibliographic solutions in research teams, benefits of knowledge sharing and building in research groups, contemporary research publications and topics, relevant publications, conferences and theories, and forthcoming publication opportunities as a path to doctoral studies. The aim is to improve future publication during the master’s thesis writing and post-graduate studies phase. As a result the every student should have 6 – 12 short papers or abstracts consisting of 2-3 pages each.

T-106.5260, the “Studio” course, is a problem-based learning (PBL) course focusing on digital end user services from technical and business concepts point of view. After completing the course, students are able to understand what kinds of services are available on the Internet and how to discover and access them. Students learn what kinds of tools and technologies exist for creating new services and are able to apply some of them in short demonstrations. Students shall acquire skills and experience in service creation process and become familiar with methods for creative, collaborative design and problem solving. The Studio course is synchronized with the Insight and Innovation courses to cover current topics that support design and engineering systems thinking in the large industrial project, especially in the early phases when students are working with complex and abstract problems.

In the T-106.5750 “Camp” course, a group of 4 – 6 students innovate a new service, taking it through all the steps from initial idea to implemented service in a maximum of two months. The core of the course consists of four intensive periods hosted in studio environments: concept camp, design camp, implementation camp, and experimentation camp. There is a strong emphasis on successful creation that depends on a balanced combination of design, technology, and business perspectives. The results of the most recent camp are presented to venture capitalists, who evaluate the projects to give the groups real-life business perspective and to identify entrepreneurial and other development opportunities for promising concepts and prototypes.

T-86.5751 is a “Service Strategies” course is focusing on contemporary Aalto University and EIT KIC ICT Labs research topics in the field of engineering systems and service science management engineering and design (SSMED). The course covers areas relevant to forming a good understanding of research work, interdependencies of different thematic topic areas,

cross-disciplinary problems, and the challenge of synthesizing and evaluating the covered service topics. The course is intended to be an arena where students can discuss and collaborate with faculty, doctoral students and post-doc researchers and receive one-to-one feedback for their current research papers in progress.

4.1 Insight and Innovation as a foundation

T-86.5415 and T-86.5416 Digital Service Insight and Innovations I/II courses together form an approximately 12 – 14 months long industrial research-to-venture project. The project is financed by the industry and done in close collaboration with the university, selected partners, and senior mentors. The two courses together take the entire first one and a half years of the master's students' study time to complete (this includes the summers if students accept the internship provided by the program). The innovation and insight lectures and assignments cover project-relevant topics, such as strategic foresight, open innovation, project management, collaboration, subcontracting, business planning, new business development, and other current topics in service innovation.

The objectives for the SDE Insight and Innovations I/II courses can be summarized as follows:

- process and experience based approach to learning
- cross cultural teamwork in global and challenging environment
- teaching systems and holistic thinking understanding
- teaching understanding about the capability and potential of different views, errors, conflicts, perceptions, and approaches as ways to works and find solutions
- design thinking through highly visual concepts
- abstracting large scale problems and complex systems to understandable systems
- using design thinking and choices in the concept development
- planning, implementation, and maintenance of the selected concepts in real-life industrial environments
- implementation and operation of a large B2Bor B2C digital service system

During these two courses, students learn how to do research on topic, conceive the problem area, design concepts, implement services, present the case for business funding and how operate it in real business environment. These two courses follow the CDIO thinking closely. Students also learn how to behave, handle and interact with a real industrial customer or public organization in the international business environment. The first course starts with open-ended project assignments, which provides students some direction for the challenge. After this student groups meet regularly with the customer to share findings and knowledge. Experienced mentor provides new and fresh views and professional insights. Executive coach from the faculty reflects the results and challenges together with the teams.

4.2 Insight and Innovation project

The students work in cross-cultural teams of 3 to 8 members for at least 12, and up to 16, months. Each team carries out a particular strategic project related to digital service development, from the perspectives of innovation, design, or engineering, to those of international market and business study. The projects are based on real business and customer needs, defined during the first phase of the project with the partner.

The project is organized around an Insight project model, which could be identified as a research-to-venture model. The Insight mapping to CDIO (see Table 1) show that the model is in alignment with CDIO.

Phases of the Insight and Innovation project	Mappind to CDIO
IS - Project kick off, team forming and research	C
I1 - Problem analysis, concept design and research syntehsis	C
I2 - Concept evaluation, focused concept study and high level prototype	D,I
I3 - POC development and concept for go-to-market	D,I
I+ Intership related to project	D,I
I4 - Proff of concept, market test and venture funding	I,O
IG - Executive and final reports	O

Table 1: Mapping the SDE with CDIO syllabus

The IS-phase initiates the project after signing the written agreement with all stakeholders. This phase covers topics of a very large scope with future challenges in mind. Students are introduced to foresight research and practical concepts through collaborative analysis of problems, joint synthesis of the findings, and team-based reporting of these findings in a classroom presentation. The purpose is to familiarize students with each other before they actually enter on the industrial premises or get into real industry interaction. Midway through this phase students are introduced to their counterparts at the industrial partner, which shall hold a presentation defining the scope and direction of students' work for the next 12 – 16 months.

The I1–phase focuses on problem analysis, generation of various alternatives, and wild ideas and concepts. The students are introduced to various idea generation techniques and methods, interviews with experts from extreme disciplines and science domains, sources of information, and use of crowd sourcing. The ideas and material are synthesized into concepts that can be presented to the industrial partner. The selection process shall include concepts generated internally by the industrial partner. The collaborative open learning model allows both parties to build on the other's ideas and to progress faster to better ideas. At the end of this phase, one or two concepts are selected for focused study and development.

The I2–phase focuses on analyzing potential new opportunities, weaknesses, trends, and strengths of the selected concepts through several different lenses to aspects that were not included in previous phases. This phase is important for student to understand the multi-causality and far-reaching impact of design decisions. The phase shall end with a design of a high-level prototype or a visualization and process model demonstrating the selected service concept for steering a group or the owners of the project.

The I3–phase emphasizes implementation of a proof of concept (working software prototype) and an analysis of go-to-market concepts for the selected concept in the decided target market. In this phase the students work very closely with the industry to gain correct impressions and data from the market. This outside industry expert knowledge and hands-on insights will give them the ability to evaluate the relevant and optimal business and prizing concepts.

The I+ phase is the summer period between the first and second year of the program. Students are offered a volunteer-based internship for 8-9 weeks at the industry partner's site. Students

are also encouraged to participate in the "Aalto product-to-service-brand" summer school that takes place in early June and to graduate from summer school in late August.

The I4–phase is a "ramping up" of the service concept to a real working test and, finally, selling the concept to internal or external venture organization. The student shall travel to a selected market area to finalize information collection from the test phase and evaluate the concept in a real life situation. This phase also acts as a research or thesis project sales opportunity for students. The students are motivated the project could give them a head start in thesis project or future employment after project completion.

The IG–phase focuses on project closure, internal sales for funding, and reporting. The best projects are granted the opportunity for presentation at a black-tie annual gala event, which will gather together all the SDE students, faculty, alumni, partners and stakeholders involved in the process. After the gala students should have only their master's thesis before graduating. Thus the collaborative learning approach and structured curriculum potentially will even help the full time master's student to graduate in advance.

4.3 Insight and Innovation reporting and assessment

The bi-monthly progress report consists of the following information:

- project description
- project goal and deliverables
- work breakdown structure (completeness and results)
- tasks completed in past two weeks
- challenges in past two weeks
- tasks for coming two weeks
- most important task in coming weeks
- issues hindering learning and progress
- weekly project hours per person
- weekly study hours per person

The faculty and industry partner evaluation focuses on the following outcomes:

- meeting milestones and objectives of each phase
- meeting minutes
- presentations
- reports
- final report

Based on these, the two Insight and Innovation courses' finally assessed give credits from 4 to 16 ECTS, depending on the effort reported during the process. The final individual grading evaluation follows the course grading guidelines set in the beginning of the course. The final evaluation is done partly by faculty members and partly by the industrial partner. The course evaluation will assess the quality of work, timely reporting, and feedback from the customer. The grading will be consist of 20% evaluation by the teachers and project mentor on students learning reflection, 30% project evaluation by the customer and group, and 50% on the biweekly progress reports, participation, and assignments. Evaluation of such projects courses is challenging.

5. PROGRAM DEVELOPMENT AND ORGANIZATION

The faculty invested in the SDE program preparation and development before the program revision and launch. The analysis of this effort can be estimated from the recorded meeting minutes, calendar markings, from the number of persons involved in each meeting and phase, and from the topics addressed during each month before and after the meetings. No exact log or recording was kept during this effort. The table 2 below shows a best estimate, based on the documents, memos, and records. The total faculty effort used in SDE preparation and development during the three-year period is estimated at between 2 and 2.5 man years.

TIME (h)	2007	2008	2009
Professors	30	155	250
Program director	0	0	624
Post.docs	48	248	160
Researcher	0	316	80
Assistant	10	116	180
TOTAL	**88**	**835**	**1294**

Table 2. SDE development effort 2008 – 2009

5.1 SDE organization, roles and responsibilities

The SDE program is supervised by a steering group, and all development activities are organized through four (4) practical working groups and separate industry projects. The steering group consists of two key professors responsible for the academic content of the program. The primary task of the chair of the steering group is to support the program director. A full time program manager is required since the program director is like a general manager in a small enterprise or start up of a new business venture in large organization.

The academic group is responsible for the integration of research into education, curriculum, international partnerships and co-operation, acceptance criteria, admissions, learning outcomes, and academic administrative issues.

The education group focuses on the content of the curriculum, learning outcome coordination, course content coordination, intra-university education co-operation, reception of new students, course delivery and student schedules for each period, social activities, delivery of the content, and collection and analysis of the feedback from the students and faculty members.

The partnership group is responsible for the marketing, negotiating, and contacting for the projects. This involves meeting with x-level executives and senior management enterprises from various functions in the companies to align the agreed-upon project with the development activities inside the enterprises during the whole lifecycle of the project.

The marketing group is responsible for promoting the program through the media, on the Internet, and in domestic and international events in co-operation with the university's other marketing and promotional activities.

The graduate research group is an independent academic research group working together with other research teams within the service science domain and the university's other research activities linked to the SDE programme.

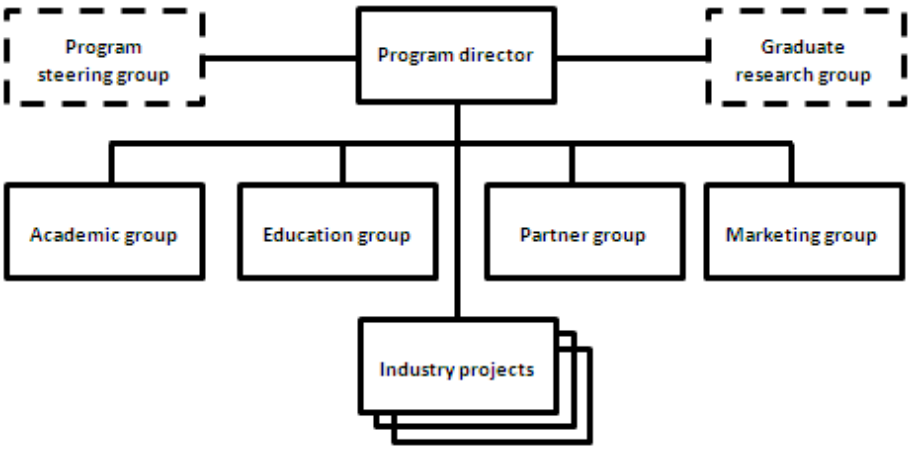

Figure 4. SDE program organization

The program director's responsibilities can be listed as follows:

- program vision, mission and strategy
- general program management
- compromising the different interest
- international marketing of the program
- financing and reporting of the program
- integration of the program with other disciplines
- new approaches to curriculum content
- enterprise project partnerships and steering groups
- enterprise contacts, negotiations and agreements
- program, module, and course level learning outcome coordination
- program and module level development
- international student coaching/ mentoring
- supervision of industry project teaching assistants
- regular assessment and continuous improvement
- ad.hoc. student well being issues and coaching

5.2 Student perspective

The Aalto University and SDE program has become the students' choice of place to study for the following reasons based on the application data and regular interviews with the student:

- demanding reputation of Aalto School of Science and Technology
- baccalaureate degree in Finland
- new interesting curriculum in service science
- other contact or previous experience with Finland or with Finnish universities
- interesting new courses and learning objectives
- other material provided with the official acceptance and information package

6. CDIO STANDARD AND SDE PROGRAM

The CDIO framework was selected as the evaluation and benchmarking framework late 2009. A very similar approach has been used at Helsinki University of Technology since early 1990's. The author has been engaged in several courses using the CDIO style framework first as early as 1984 in Everett, WA high school physics class etc. "*an egg in a shoe box experiment*" and later during university education (e.g., IDBM and PDP) using practice oriented frameworks in projects such as intelligent valve control systems, digital heart sound recorder, reliable electronic industry display for medical and military use, luxury communication devices, and global segmentation of consumer electronics products, during studies at Helsinki University of Technology, Finland, and at The Royal Institute of Technology, Sweden.

The CDIO framework was selected because it has provided good experiences within the university, and it is well recognized and valued by the engineering schools. The framework can be applied in curriculum development, in evaluation of the curriculum, and as a pre-assessment framework for international engineering accreditations such as ABET.

12 CDIO Standards	Self Assessment
1: CDIO as Context*	4
2: CDIO Syllabus Outcomes*	3
3: Integrated Curriculum*	5
4: Introduction to Engineering	5
5: Design-Build Experiences*	5
6: CDIO Workspaces	5
7: Integrated Learning Experiences*	5
8: Active Learning	5
9: Enhancement of Faculty CDIO Skills*	3
10: Enhancement of Faculty Teaching Skills	4
11: CDIO Skills Assessment*	3
12: CDIO Program Evaluation	3
*13: International**	5
SDE CDIO self-assessment	**4,2**

Table 3. SDE program self-assessment

Areas identified for improvement will be addressed during the 2010 – 2011 academic year. Certain limitations may slow progress, as follows:

- faculty time and resources for education development
- lack of programme level learning outcome assessment
- program level course assessment model and information system supporting planning, development and assessment process

7. DISCUSSION

The SDE program has been an agile innovation project inside Aalto University. The introduction of the T-86.5415 and T-86.5416 Digital Service Insight and Innovations I/II courses, together with the T-86.5200 Service research seminar, have extended SDE programme to meet the CDIO initiative requirements. Figure 5 has proposed several extensions to CDIO framework to meet the master's level requirements. As a summary the CDIO framework should be extended (see Figure 5) with the following:

5. Internships
6. Scientific publishing
7. Systems and process leadership
8. Engineering and entrepreneurship strive
9. Role of engineering knowledge in society

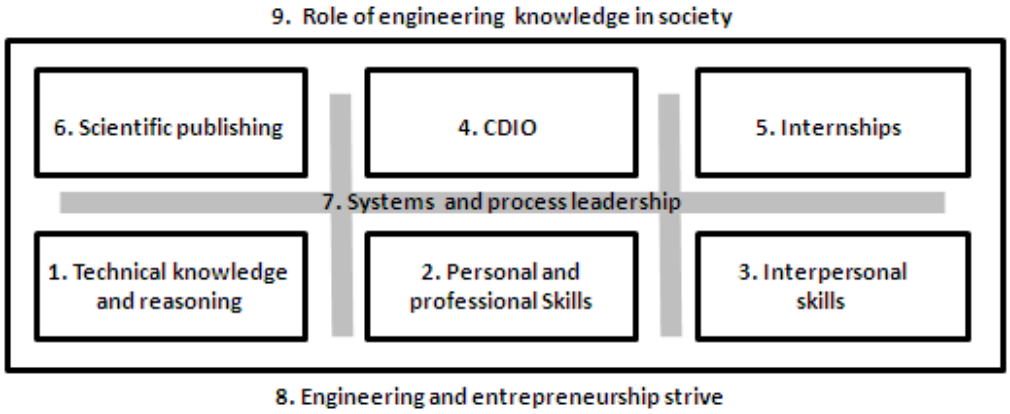

Figure 5. Evolutionary CDIO Syllabus with new elements

8. CONCLUSION

This paper presents the development of a new cross-disciplinary SDE master's program in the newly evolving field of service science. The CDIO framework is applied to evaluate the SDE program. The paper also demonstrates how the SDE program fulfils CDIO standards. The evolution of the syllabus is analyzed in this paper using the CDIO model. The paper also proposes new elements for the CDIO syllabus as part of the next generation of engineering education. The future development and research work should involve assessment of the SDE with CDIO Syllabus and ABET.

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Biographical Information

Mika Helenius, M.Sc.(Tech), Director, chief program officer, head of education in Aalto Service Factory (ASF), member of EIT ICT Lab education area project, postgraduate researcher, lecturer and Ph.D. & MBA student. He was awarded 2010 by the number one finish ICT newspaper "Tietoviikko" (Information Week) as the most influential ICT professional of the year in Finland. His current work involves management of the newly established international information management and digital technology focused “Service Design and Engineering” (SDE) postgraduate masters program in the Aalto University. The program will closely co-operate with leading ICT, telecom and internet service companies in the world. He is proactive innovation and education development evangelist with the university, industry, public organizations and own community.

While studying for the degree he started to work for Helsinki University of Technology as research assistant, research coordinator and lecturer. After graduating he managed Nokia’s future foresight research project as post graduate student. He has worked in management since with companies like Audi, Metso, Fujitsu, Lotus, IBM, Mermit and Ixonos. Before joining the academic faculty early 2009 he worked nearly ten years with Mermit. Company he first founded and then managed to become the leading ICT and ISM services and consulting company “according to public organizations study” in Finland. Nearly 100 person professional services consulting company was working with customer in telecom, medical, banking, finance, public, security and retail industries mainly in Europe. His has held position in national Federal Architecture Development Committee, worked as senior advisor for several ministries and top executives/boards and as editor in chief of an ICT consulting magazine.

More information: http://www.linkedin.com/in/mikahelenius

Corresponding author

Mika Helenius
Aalto University / School of Science and Technology
Department of Computer Science and Engineering (CSE)
Tekniikatie 14
FIN-02150 ESPOO
Finland
Tel: +358-50-64432
email: firstname.lastname (at) tkk.fi