CDIO IMPLEMENTATION IN THE ICT ENGINEERING CURRICULUM – SEMESTER PROJECTS

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ABSTRACT

CDIO has been in the center of the new curriculum development for the ICT department of Lapland University of Applied Sciences since the year 2013. The first step was to adopt the principle that CDIO is the context of ICT engineering education and then ICT department determined the outcomes for learning of the skills associated outlined in the CDIO Syllabus. ICT program was also benchmarked against more experienced CDIO implementers to learn from the best practices.

Since then continuous improvement has been done to enhance the ICT department competence in CDIO skills. In the latest self-evaluation three main areas for improvement were identified to satisfy CDIO standards 5 (Design-Implement Experiences), 9 (Enhancement of Faculty Competence) and 11 (Learning Assessment). This document describes how the development work has been done.

While starting from the existing curriculum it was decided that the new curriculum based on project-based learning (PBL) would be piloted with selected courses. The real-life projects were from local companies and the University's cooperation R&D&I (Research, Development and Innovation) projects.

The new Curriculum in the pilot was decided to be based on 30 ECTS credits semester projects due to results of piloting other options as well. Named teacher teams who will also implement the future projects designed Eight (8) semesters. Each team was comprised of professors from various fields. The teacher team planned the integration of the selected courses for each semester – semester-based projects. Students learned to use modern project management techniques like Agile, Scrum, Kanban, Lean – skills what ICT Engineers need after finishing their studies.

The first real-life R&D&I learning projects piloted in the curriculum development support also the Lapland UAS strategy, e.g. eSled (the electric snowmobile), iLodge (intelligent Lodge for tourists) and Digital Trekking Services on the Arctic Circle. These projects are described more detailed in this document.

KEYWORDS

Curriculum, integration, semester project, case study, continuous improvement. CDIO Standards: 5., 9., 11.

INTRODUCTION

The focus of this paper is to present the results of the CDIO self-evaluation and some actions to improve them. Three semester projects will be presented as case studies. All courses were integrated during this curriculum development process. The publication is a perspective and a summary of teachers' actions and results to achieve higher CDIO level.

Self-evaluation is one part of the quality assessment of School of Industry and Natural Resources, Degree Program of ICT in Lapland University of Applied Sciences. Regular evaluations are used for developing operations and reaching the goals set by OKM (Ministry of Education and Culture) for the universities of applied sciences. These goals include e.g. maximizing the number of graduates and minimizing the number drop-outs, accomplishing 55 ECTS per year, and the overall student satisfaction (coming to the financial model). The assessment is presented at the education planning event. The teachers and R&D&I employees of the Lapland University of Applied Sciences participate the event.

SELF-EVALUATION

The first self-evaluation, applying to all CDIO principles, was made at the education planning event in October 2013. Principles 5, 9, and 11 were chosen as special areas of development based on the self-evaluation. The special areas of development were re-evaluated in the intermediate assessment of 2015, but no significant change was observed. The self-evaluation was again done for all areas of development at the end of 2017, including the three special areas.

The results of the self-evaluation are presented in table 1. The mid-term assessment of 2015 was done only for the three special areas of development, so these results are not presented in the figure.

Table 1. The assessment levels in 2013 and 2017. (The scale is 0-5 according to the CDIO Standards 2.0).

	Assessment level in 2013	Assessment level in 2017	Difference
Principle 1 The context	2	3	+1
Principle 2 Learning outcomes	2	3	+1
Principle 3 Integrated Curriculum	3	4	+1
Principle 4 Introduction to Engineering	3	4	+1
Principle 5 Design-Implement Experiences	3	5	+2
Principle 6 Engineering Workspaces	4	4	0
Principle 7 Integrated Learning Experiences	2	2	0
Principle 8 Active Learning	1	3	+2
Principle 9 Enhancement of Faculty Competence	0	1	+1
Principle 10 Enhancement of Faculty Teaching Competence	1	1	0
Principle 11 Learning Assessment	1	1	0
Principle 12 Program Evaluation	1	1	0

In 2013, the new curriculum was carried out. The new curriculum was based on project-based learning (PBL). For this reason, the following special areas of development were chosen for first development targets:

- Principle 5: Design-implement-test Project
- Principle 9: Enhancement of Faculty Competence
- Principle 11: Assessment of Learning

To enhance the level of principle 5, the degree program implemented several projects under the CDIO Framework. The principle 9 has been sided eg. by running supervisor-based discussions, and about the principle 11, the training of the improving assessment has been organized by the university.

Several projects, based on the CDIO principles, were designed and implemented to the higher level in the Principle 5. The first pilot project was carried out in spring 2014. During 2015-2016 several study modules were integrated into the projects and several seasonal projects were carried out. In 2017, all spring study modules were integrated to seasonal projects and the teachers operated as a teaching team. Examples of seasonal projects are presented later on in this document.

Special pedagogical training was provided for assessing learning and the special areas of development in teaching by the University of Applied Sciences. Project-based learning became the standard in teaching. The development of the curriculum was supported by local industry representatives and students representatives.

Based on the results, the teachers' proficiency in CDIO (principle 9) was slightly improved. In addition to the teachers' professional skills, system building skills and process and product skills, the interpersonal skills were improved. The teachers learned how to work in teams opposed to working alone without consulting other teachers. Carrying out seasonal projects (30 ECTS) should be treated as a project itself, as they require planning, management, and coordination on the teacher team's side. Teamwork among teachers is gaining more and more traction, although there are some exceptions. Supervisor-based discussions and support are very important during this process. The development of teachers' CDIO skills should still be more systematic.

Integrating study modules to projects has resulted in increased versatility in teachers' work, although it has become more demanding than before. In addition, the number of graduates and students that have accomplished 55 ECTS per year has increased after the CDIO and project-based learning was introduced.

Planning long-term teaching development is seen as necessary, as planning is still targeted towards individuals' needs, not the education itself. Monitoring OKM's targets are in active use in education, but it does not support development. Education should be assessed in the context of the development plan.

In order to achieve higher assessment levels, teachers of the degree program suggested as an improvement to receive feedback from external assessment and reviews on seasonal projects. The external assessment could be implemented as cross-reviews between other degree programmes in the school of technology. The subject is under development.

NEW CURRICULUM - SEMESTER PROJECTS

The new ICT Curriculum is based on 30 ECTS credits semester projects due to results of piloting other options as well. There are lot of experiences of project-based learning, for example, Mejtoft et. Al (2015). Learning projects are based on an agreement with either local industry or University's R&D&I (Research, Development and Innovation) projects. Eight (8) semesters were designed by named teams of teachers who will also implement the future projects. Each team was comprised of professors from various fields (Angelva et al., 2017).

Each semester is planned around a project as shown in Figure 1. The learning project is supported by the other courses of the semester. The courses are integrated into the projects to meet learning outcomes and build upon the know-how intended for the semester along with the project.

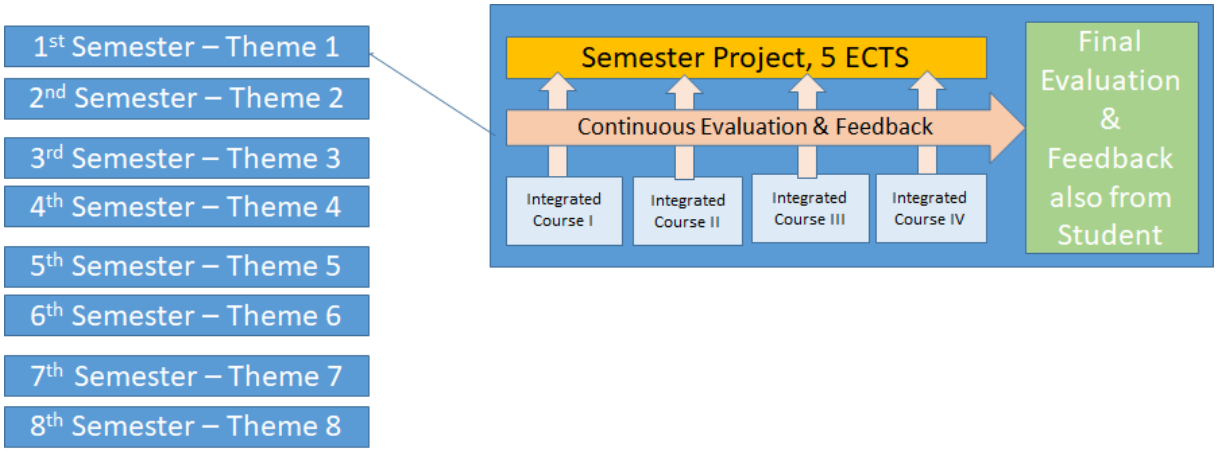

Figure 1. Fundamentals of the Semester Structure in Curriculum (Angelva et al. (2017)).

Learning Project Management

Learning projects are managed using appropriate tools. During the first integrated learning courses, project management is done and learned according to PMI's (Project Management Institute) PMBOK Guide (Project Management Body of Knowledge). While students skills have developed in project management, agile methods like Scrum is taken to use. Figure 2. shows how Scrum is implemented in the learning project.

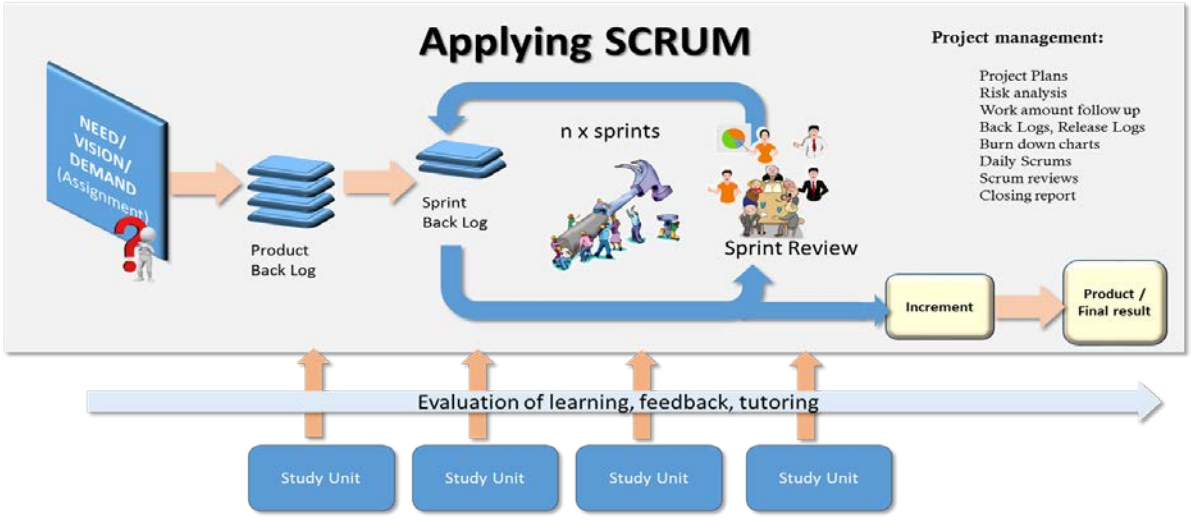

Figure 2. Using SCRUM in integrated learning projects

The organization model is chosen for the learning project, for example, a generic project management and implementation model or one of the agile methods, e.g. SCRUM. SCRUM method is widely used in other Universities as well. For example, Turku University of Applied Sciences (Kontio et al. (2017)), is using it in teaching. The teacher team makes decisions on, among other things, the times to start and end, the number of mutual reviews, ways of guidance, etc. The timing for each of the courses that support the project is defined.

Students feedback about these projects followed the experiences according to Kontio et al. (2017):

- Projects are a good way to learn
- Working with stakeholders is valuable and good training
- Projects support understanding the lectures
- Working with real-world projects support to develop professional skills
- Some projects are too demanding

CASE STUDIES

CASE 1 - Smart Cabin

The basics of project management are studied during the first year's seasonal project. The first year's spring project is called Smart Cabin, in which the students implement demos of automated houses. The demos are presented for surrogate clients at the end of the project. Study modules integrated to the seasonal project are presented in figure 3.

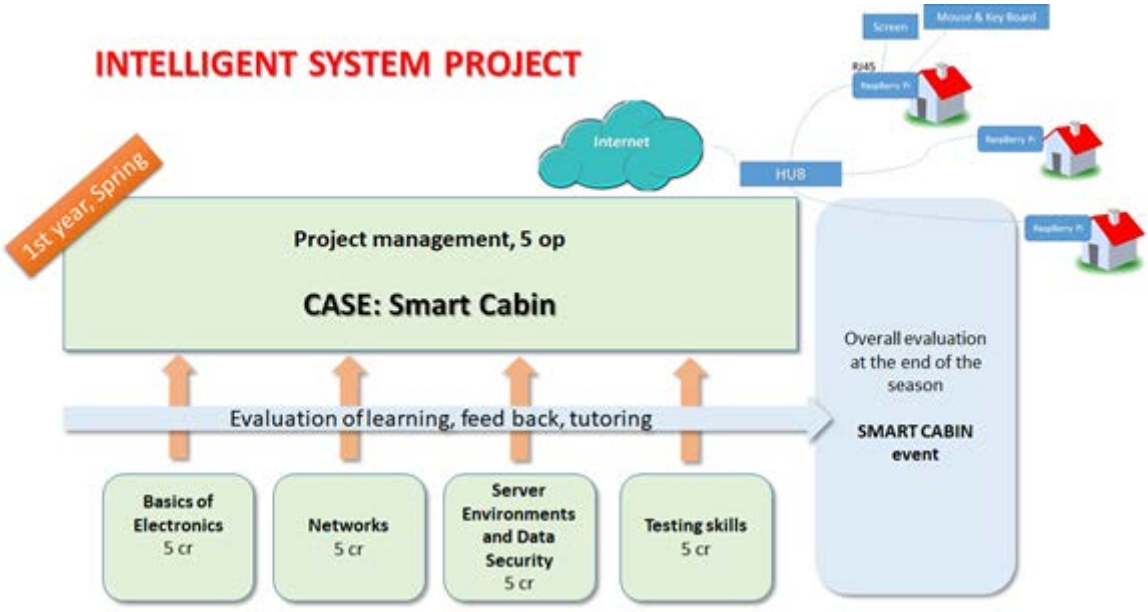

Figure 3. The first year's seasonal project and the integrated study modules.

Automated houses are implemented using technologies compatible with Raspberry Pi computers. The system should be able to measure sensor information, it should be monitored via a website, and the potential security risks should be assessed. The system should be disguised as miniature houses. The houses are combined to an exposition and they were all connected to a common network (Figure 4).

Figure 4. Exposition of miniature automated houses

CASE 2 - UI for eSLED

The third year's seasonal project is organized in co-operation with the R&D personnel, in which case the students are gain experience on working with a customer. On the other hand, the results of the project will also benefit the client, as the students are working on a real-life problem.

In spring 2016, the third year's seasonal project was provided by the Arctic Power Laboratory, the Center of Cold Climate Engineering of Lapland University of Applied Sciences. Arctic Power requested for an implementation of a control and measure system for an electronic snowmobile, and a mobile UI (Figure 5). More detailed description of the previous development project can be found in the publication of Kantola et al (Kantola et al, 2014)

The target of the UI for the eSLED project was develop a user interface to control and monitor systems of the electric snowmobile. Interface visualize real-time dashboard to driving control. For later analysis, there also should be a possibility to send data from the vehicle from terrain to database through telecommunication channel e.g. 3G mobile phones or by using GPRS.

Figure 5. The third year's students working on the eSLED by K. Karlsson.

Measurement technology project - UI for eSled combines mobile technology-oriented course to practical lab course where students must design all layers which are needed to implement measurements to monitor and control of the complicated electric driven vehicle.

Figure 6. presents integrated study model of 3rd-year students project related to the seasonal project. All 5 ECTS was a part of the project. Individual study units were evaluated separately. The project was evaluated end of the season by teaching team, which was consist teachers of individual study units.

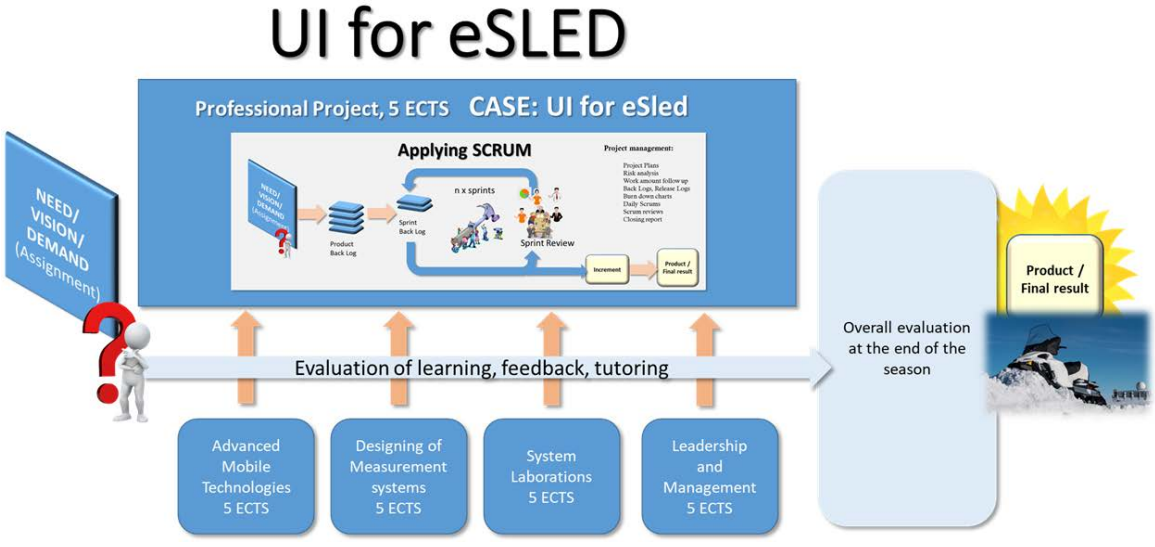

Figure 6. The integrated study modules in spring 2016.

The project management method of seasonal projects during the second and third year is SCRUM. The project is divided into phases, which are called sprints in SCRUM. Each sprint is

reviewed by a team consisting of teachers and R&D employees, which act as customer representatives in the project. The duration of a spring is approximately 2-3 weeks. Student groups present a demo of the sprint's results in half-hour Sprint Review sessions. The teacher team consists of the teachers responsible for the integrated study modules. The learning requirements of each study module are reviewed by the results of the project. During the reviews, students receive feedback and guidance and they can gain experience in working with a customer.

DTS – Digital Trekking Services

In spring 2017, the seasonal project was provided by a project called LuontoRovaniemi, which is organized in cooperation of Arctic Power laboratory and software engineering laboratory PLAB. The city of Rovaniemi and Metsähallitus (*Finnish Administration of Forests*) were also involved in the project.
The goal of the project was to create a brand for the eco-tourism in Rovaniemi area and to bring up the therapeutic elements and well-being effects of the arctic nature though branding and electronic marketing. The goal of the students' seasonal project was to innovate mobile applications for e.g. maintenance and development of trekking trail network.
In spring 2017, the third year's sixth semester contained the study modules presented in figure 7. The study modules were integrated into a study module called Professional Project.

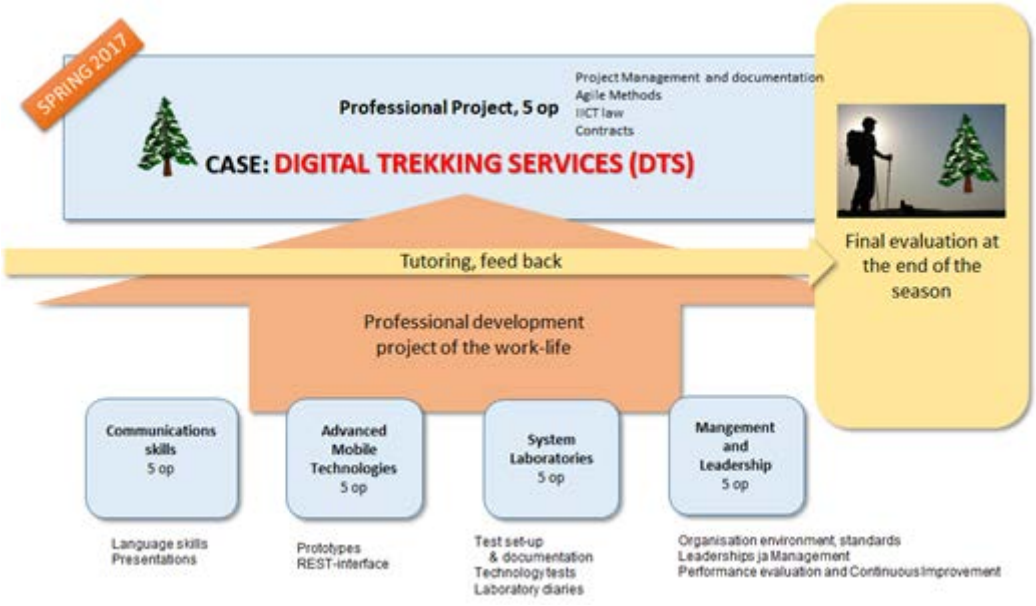

Figure 7. The integrated study modules in spring 2017.

Student presented the prototypes at a fair organized by the degree programme. The public of the fair consisted of students, the personnel of the degree programme and the R&D team. Representatives of Rovaniemi city and Metsähallitus were also invited to join the fair as special guests.

CONCLUSIONS

Self-evaluation based on CDIO continuous improvement process was done in three phases, 2013, 2015 and 2017 respectively. Special areas of development were chosen as can be seen in Table 1. Principles 5, 9, and 11 were improved in the comparison between 2013 and 2017. Teachers' proficiency in CDIO skills (principle 9) was slightly improved. In addition to the teachers' professional skills, system building skills and process and product skills, the interpersonal skills were improved. The new curriculum of the ICT degree programme contains the CDIO and project-based working method as leading standard. The method will be applied for all future ICT groups intaken. All study units will be integrated into the seasonal projects. The process will be further improved according to the continuous development principles. Next self-evaluation is going to be implemented in the year 2019.

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BIOGRAPHICAL INFORMATION

Tauno Tepsa is a Senior Lecturer in ICT Department at the Lapland University of the Applied Sciences. His main focus is on electronics and embedded systems being responsible for the lecturing of those topics. Continuing research of switch-mode power supplies and embedded electronics and participating in development projects belong to his everyday work.

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