# CAPSTONE INNOVATION PROJECT – PEDAGOGICAL MODEL AND METHODS

**Riikka Kulmala[1], Mika Luimula[2], Janne Roslöf[3]**

Faculty of Business, ICT and Life Sciences, Turku University of Applied Sciences, Finland
[1] riikka.kulmala@turkuamk.fi, [2] mika.luimula@turkuamk.fi, [3] janne.roslof@turkuamk.fi

## ABSTRACT

In autumn 2012, a new Capstone Innovation Project course based on the CDIO framework was piloted at Turku University of Applied Sciences (TUAS). Encouraged by the positive experience from the first pilot projects, the course was extended in autumn 2013 to cover a larger group of the students of the Bachelor's programmes in Information Technology, Electronics, Business and Library and Information services. The innovation project is implemented in multidisciplinary teams of 6-8 mainly 3rd year students. The course allows students to develop a prototype solution to a problem or need of a real client. The project covers the whole life cycle of a product development process from an initial idea phase to closing the project. The pedagogical framework of the course includes innovation pedagogy, problem-based learning (PBL) and project-based learning. User-centred methods are applied in the planning phase of the project, and agile methods, especially Scrum, are used in project implementation. This paper presents a case study describing the current experiences of this extended course pilot, details the pedagogical process used and methods applied in different phases of the projects (idea generation, rapid prototyping, implementation, closing), as well as the learning experience and strategies for effective and realistic competence-based assessment. The feedback analysis from the pilot course showed that the innovation project was considered to be highly motivating, challenging and educating. The aim of this paper is to define pedagogical models and methods that support motivation, learning, team cohesion and collaborative, user-centred development process.

## KEYWORDS

Innovation pedagogy, Assessment, User-centred Development, ICT, Scrum, Standards: 3, 5, 7, 8

## INTRODUCTION

The ICT Engineering education at TUAS has a long tradition of active educational development. Examples of our development steps before joining CDIO in 2007 include application of problem-based learning in different courses especially in the first year engineering studies. Experiences on these activities have been documented in several publications (Tuohi & Roslöf, 2007 and 2006; Roslöf & Tuohi, 2005). As one of the first curricular and methodological changes facilitated by CDIO, a first-year "Introduction to Engineering" project course was introduced into the curriculum (Saarenpää & Tuohi, 2010; Roslöf, 2008). The first implementation of this course was run in autumn 2009 and after

some further modifications it has been quite successful. Today, this course is one of the leading courses of the first-year students. Other CDIO-inspired advances implemented during the past few years both on degree programme and on faculty levels include, for example, further development of faculty competences both in terms of subject knowledge and learning and teaching skills, improvement of workspaces, and efforts in quality assurance activities (see e.g. Kontio et. al, 2012; Kontio, 2009).

According to the CDIO standard number five (CDIO, 2010), a CDIO programme curriculum should include two or more design-implement experiences, including one at a basic level and one at an advanced level. In addition to the first-year introductory project course, the curriculums of TUAS ICT degree programmes have traditionally included several project-based options. Several different courses contain projects, and the students can include project-based activities as optional parts of their degree. The experiences of using projects as efficient learning platforms have been good. An example of notable results in this field is that TUAS project teams have been successful in international technology competitions many times (Roslöf, 2013). Yet, there has been no integrated advanced-level project course in the curriculums. That is, active students have been able to participate in projects also at advanced level but, on the other hand, it has been possible not to take these opportunities. Furthermore, there has been no clear process to coach, execute and assess these projects.

The development need concerning the advanced-level Capstone project in particular was identified as a part of the stepwise CDIO adaptation process self-evaluation of our degree programme curriculums. The topic was widely discussed with international colleagues during the 6th International CDIO Conference in Montreal in the summer of 2010. Encouraged by the experiences from other collaborators, it was decided to introduce a Capstone course into the next curriculum update. The course description together with certain other curricular changes was designed during the following year and, finally, a third-year course called Innovation Project (12 ECTS credits) was included in the Curriculum 2012, i.e. the new project course would concern all third-year students for the first time during the academic year 2014-2015.

When the Innovation Project course will be started for the first time according to the new curriculum in autumn 2014, there will be a significant number of advanced student projects launching and running simultaneously. Even though there is a long tradition of implementing different types of student projects, this still means a novel mindset and sets requirements for well-planned processes to initiate, guide, manage, report and assess the projects. Accordingly, it was decided to plan and pilot the course framework well before the first “real” implementation round concerning all students. The first pilot phase was run during the academic year 2012-2013 and it consisted of only two multidisciplinary teams of volunteer students. The main goal of the first pilot was to design and test the course structure and the project steering process model. Based on the encouraging results and experiences of these projects, an extended pilot with more students and external project assignments was started autumn 2013. This second pilot is currently ongoing, and its most important goal is to improve the course practices to such an extent that it is possible to start full scale activities in autumn 2014.

In this paper, the second phase of the Capstone project course pilot in particular is presented. The pedagogical process used and methods applied in different phases of the student projects (idea generation, rapid prototyping, implementation and closing), the learning experiences, as well as the strategies for effective and realistic competence-based assessment are described and discussed.

## STRUCTURE OF THE BACHELOR PROGRAMMES

The second extended round of Capstone Innovation Projects is piloted with students of the Bachelor's programmes in Information Technology (240 ECTS), Electronics (240 ECTS), Library and Information Services (210 ECTS) and Business (210 ECTS). Majority of the students participating, 50 out of 70, are studying in the Information Technology programme. The curriculums of the programmes are structured fairly similarly including basic, professional and optional studies. As an example, the structure of the Information Technology programme is outlined in Figure 1.

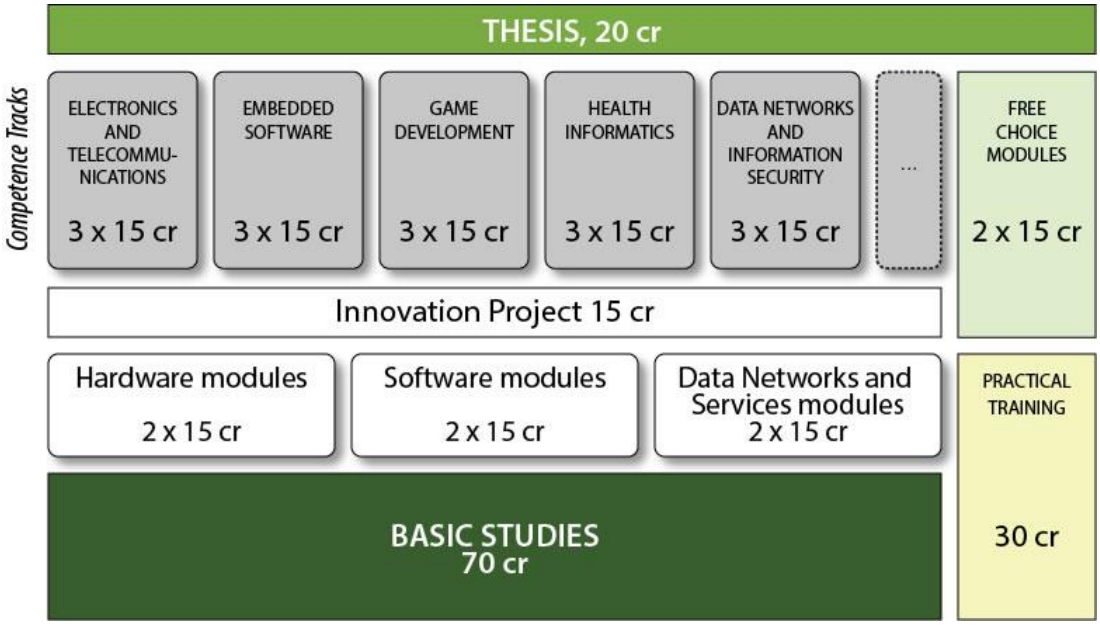


Figure 1. Structure of ICT Engineering programme curriculum

The CDIO Capstone project, called Innovation Project course, is a mandatory common professional course in the curriculum 2014. In the future, the course will take place in the third academic year in the Engineering programmes and second academic year in the Business programmes.

## PEDAGOGICAL FRAMEWORK

Capstone projects are designed to encourage students to think critically, solve and find solutions to challenging real word problems, test new ideas in a user-centred way and develop skills such as oral communication, team work, project management and networking. Projects are team-based, cross-cultural and multidisciplinary, composed of 6-8 members. Interdisciplinary and multiculturalism requires that students work in English and apply skills and investigate issues outside their own core competence (substance) area. The extent of the course is 25 work weeks and 12 credits (ECTS). Accordingly, the theoretical student workload is ca. 320 hours (1 credit corresponds to 27 hours of student work). Within this limited period of time, the student teams need to create a solution meeting the client's need. The final deliverable(s) can take a variety of forms from project to project. The outcome can be, for example, a video or animation, a service concept, a product prototype or a game demonstration.

The pedagogical framework was designed to support innovation and development processes, teamwork, experimental learning and interdisciplinary creative collaboration. The Capstone project builds on both strengthening the students' existing basis in terms of subject knowledge, and further aiming at interdisciplinary, innovative project work. The pedagogical framework is based on project pedagogy (project-based learning), problem-based learning (PBL) and innovation pedagogy.

Problem-based learning (PBL) is an active, student-centred learning method. Learning is typically group-based and experimental which means that the students will learn about the subject through the experience of problem solving (Hmelo-Silver, 2004). The tutor's role is to facilitate teamwork and guide the group in problem solving and support learning and team cohesion. Project pedagogy is closely linked to PBL and it is also an experimental and active learning method by its nature. According to project pedagogy, teaching is group-based and organised in the form of a project when the learning process follows the project process and life-cycle. The essential nature of project-type work is non-recurrence and a pre-defined timeframe. Project pedagogy simulates real-world processes and, thus, supports collaboration between education and working life. Projects strengthen students' self-direction, intentional and active learning skills and support an attitude towards understanding of shared expertise (Vesterinen, P. 2001). Respectively, innovation pedagogy provides a framework for active and experimental learning, supports regional development, interdisciplinary teaching, and promotes entrepreneurship. Innovation pedagogy encourages innovative approach to teaching and learning as well as enthusiasm for trying new methods (Lehto & al. 2011).

## CAPSTONE INNOVATION PROJECT COURSE

Altogether 15 innovation projects were launched on 30th October 2013. These projects will run simultaneously until mid-April 2014 and they should culminate in a final product or service concept. Ideally, the project idea should come from an external client which will make the assignment more "real". However, there are different points of views and disagreement on this issue (see e.g. Armstrong et al., 2005). Nevertheless, based on our experience, the students are often less committed and motivated when the institution or the students themselves have the ownership of the project and there is no or only a weak "real world" connection. Working with real customers makes the situation concrete and the teams need to negotiate with clients about deadlines, content and the quality of the work. This environment also teaches students to deal with uncertainty (Alarcon et al. 2013). Still, the students are encouraged to come up with their own ideas, too. That facilitates developing their own start-up ideas in a field of their own interest and enthusiasm. Most of the currently ongoing Capstone projects (13 out of 15) are assigned by external companies or organisations.

As mentioned earlier, Capstone projects may take wide variety of forms. The only requirements set for the project ideas are they need to be challenging enough and support competence development of the degree programmes involved in the Capstone course. When the course started, the project ideas were presented for the students in a poster exhibition known as *Capstone Fairs*. The project owners (clients) presented their projects and were available to give further information about the nature and content of the project and about the background organisation. The students were asked to prioritise the three most tempting and interesting projects from their own perspective and name one project that they found the least interesting. Finally, all the students were placed in a project amongst their top three.

The Capstone project course simulates the innovation process and the process that a start-up company would go through to launch a new product or service (Armstrong et al, 2005). This brings together both business and technical issues. The business side seeks to answer the question "*What is the value of the idea for a potential client* and *would s/he be prepared to pay for it*?", while the technical side focuses on technical feasibility of the idea. An essential part of the learning process is to teach a user-centred development process and to allow students to experience what works by testing and prototyping the idea. A series of lectures were provided on subjects of general relevance to the student's project aiming to systematically support management of the innovation process. These lectures addressed topics such as innovation processes, investigating needs and modelling, idea generation, user-centred development and methods of service design, rapid prototyping, agile project management and team building. The structure of the course and the topics of the lectures were planned to support the innovation process cycle and a lean type of start-up process (Ries, 2013; Langdon 2013).

The course is divided in three main phases: Vision, Realisation and Start-Up. The Vision phase follows a Lean start-up process from idea generation to rapid prototyping and vision building (Ries, 2013). The Realisation phase focuses on the project implementation, and it is implemented according to the principles and values of agile development using Scrum as the project management method. The Realisation phase consists of seven two weeks sprints, i.e. the length of the period is 14 weeks in total. The final phase of the course is "Start-Up" that focuses on reflection and evaluates potential spin-off or start-up opportunities. Even though the course is time-boxed and structured to proceed logically and in a linear fashion, actions taken within the course follow the typical agile development process *plan-do-test-evaluate* (see e.g. Sutherland & Schwaber, 2007). The course structure and the expected outcomes from each phase are described in Figure 2.

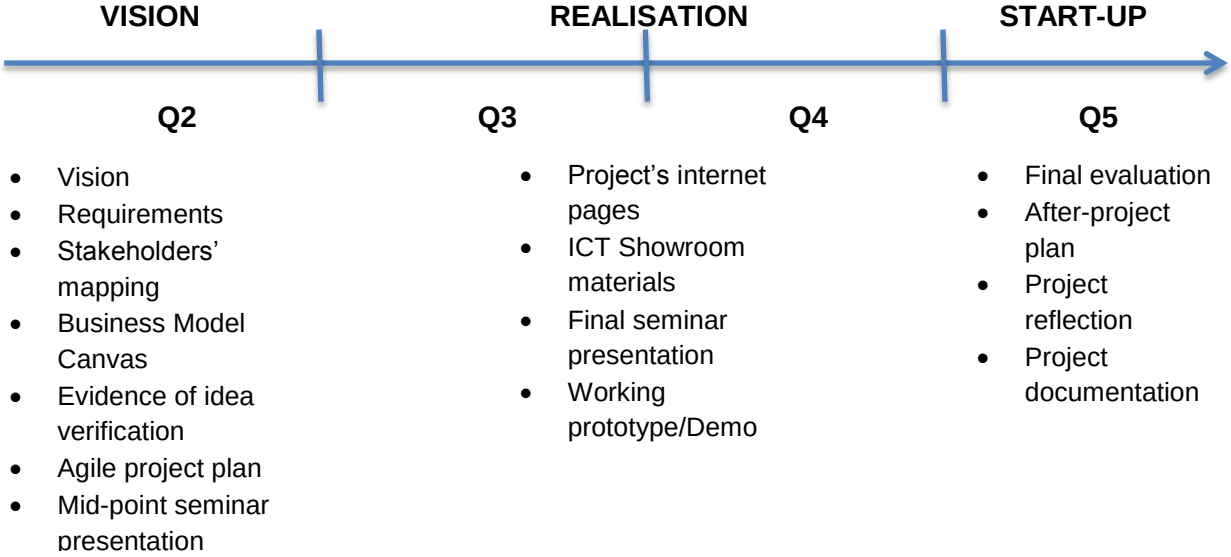


Figure 2. Capstone course structure and outcomes from each phase

The first TUAS Capstone pilot phase (2012-2013) was mainly designed based on the LIPS project management model (Svensson & Gunnarsson, 2001). The strength of this model is especially in documentation and strict deadlines. Two TUAS teachers studied for Scrum

certificates during spring 2013. Based on this experience and discussions with experts the in product development area, some changes were made to the applied project management methods. Certain valuable parts from the LIPS model such as team rules and the letter of agreement between the team members are still used. Instead of using the series of deadlines, it was believed that the use of Scrum would help the students to begin their implementation and prototyping phase a bit earlier. In addition, it was expected that students would be able to do rapid prototyping more efficiently in test-generate cycles. Moreover, majority of the on-going Capstone projects contain software development, and then Scrum provides a flexible and holistic framework for project management and engages the product owner (client) in the development process (see e.g. Schwaber, 2003). Only a few students had experience or knowledge on Scrum before starting the Capstone course. To secure a sufficient basis for starting to use Scrum in project management; lectures about agile methods and the Scrum process were provided at the beginning of the Realisation phase. To demonstrate the Scrum process, a Scrum LEGO City Game (cf. Agile42). Both tutors and students found the Lego game to be highly educational and a fun way to learn about Scrum.

“Start-up” is the final phase of the Capstone project. The phase was named “Start-Up” to raise interest in entrepreneurship. One of the significant national objectives in Finland is to increase the number of students who employ themselves as entrepreneurs. Our students should be better prepared and more confident about starting their own development projects after completing the Capstone course in a challenging project environment. The Start-up phase will focus on closing the project and evaluating the future potential and application areas. Also the whole process is assessed by project owners (clients), tutors and students.

## ASSESSMENT

During the first Capstone pilot phase, it was recognised that the assessment of the projects needs to include different types of competences. As stated in the CDIO standard 11 (CDIO, 2010), assessment should cover student learning in personal, interpersonal, product and system building skills, as well as in disciplinary knowledge. Use of multiple methods and including different perspectives facilitates an effective, realistic and holistic competence-based assessment. To secure a fair, objective and comparable assessment, templates with structured questions were used in each phase of evaluation. The assessment areas and their weight in overall grade are presented in Table 1.

Table 1. Assessment

| Areas of evaluation | Weight | Peer-evaluation | Self-evaluation | PO’s evaluation | Seminar I | Seminar II | ICT-showroom | Tutor/ expert evaluation |
|---|---|---|---|---|---|---|---|---|
| Team work | 20% | 30% | 30% | | | | | 40% |
| Project management & documentation | 20% | | | | | | | 100% |
| Presentation & communication skills | 15% | | | | 33% | 33% | 34% | |
| Outcome of the project | 30% | | | 100% | | | | |
| Degree programme based competences | 15% | | 30% | | | | | 70% |

## FUTURE DIRECTIONS

One of the ultimate objectives of the Capstone projects is to build a bridge towards entrepreneurship for the students. Our campus is located in a regional science park which is a nurturing environment for new start-ups. Our second round of Capstone pilots is still in progress, and it is too early to estimate how many projects will be vital for start-up journeys arranged by Boost Turku, a student-based network for young entrepreneurs and entrepreneur-minded people in Turku (Boost Turku, 2014).

For example, the game industry is one of the most rapidly growing sectors in Turku area. Therefore, Boost Turku has plans to organise a specific game start-up journey this summer. In Figure 3, a model of how game development projects (including some Capstone projects as well) could be further developed to fulfil the requirements of participation for the game start-up journey is described. ICT Showroom (a local student project exhibition and competition event) is the place where the project groups will have a chance to demonstrate their results, and to receive valuable feedback from companies and other stakeholders including Boost Turku representatives.

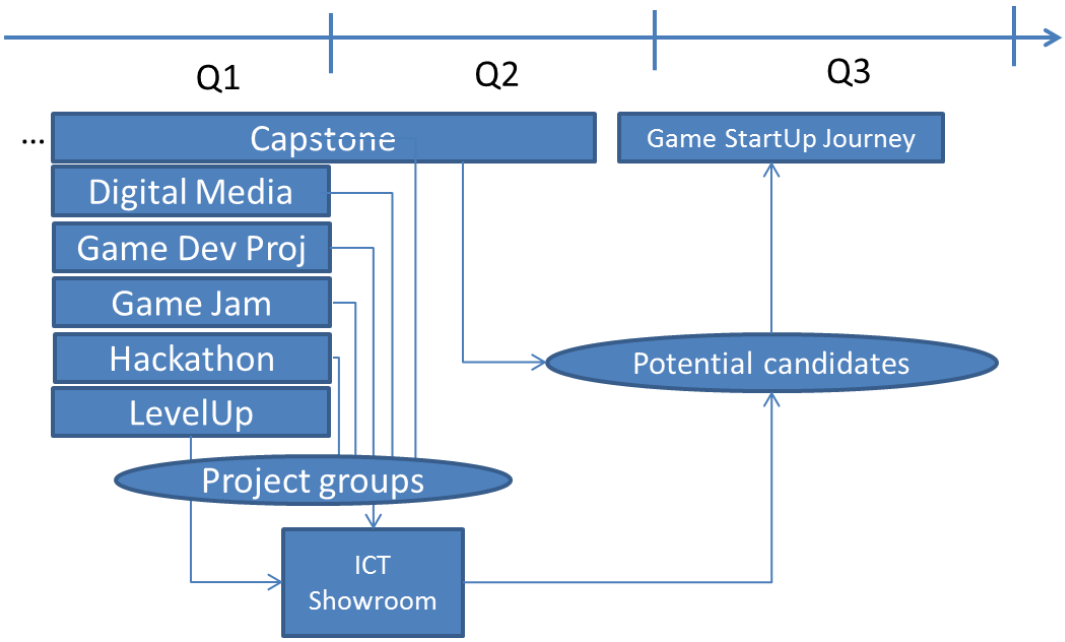


Figure 3. A model to boost students towards entrepreneurship after the Capstone.

The use of innovation pedagogy has a lot of potential. However, many times projects even with promising results and satisfied customers will be forgotten. As visualised in Figure 3 our Innovation Project course will last until late spring 2014. At the end, the objective will offer students possibilities to find solutions with regard to how to continue their work in one way or another. That is, during the final weeks of Capstone projects the students have to negotiate together with their customers what the next steps could be. There are many options available. Therefore, it is relevant to participate actively in these negotiations with the customers who have shown interest for the results and further discussions. The students can continue the activities, for example, during their work placement or thesis projects. Sometimes this can be supported with external funding resources as well.

## CONCLUSIONS

In the first pilot phase, was found that the students were some way “over planning”. That is to say, the students had difficulties moving from the idea generation and planning phase to the rapid prototyping and implementation phase. Therefore, Scrum was found to be a useful tool to push students towards this phase, and it also made it easier to commit the product owner and potential users to the development process. Although the Lean process and Scrum are used in this second pilot, it seems that one of the most difficult tasks for many student teams is stepping out from the university to meet potential clients and users to test and prototype the initial idea. Also turning the vision into concrete actions and tasks that will lead to a concrete prototype solution seems to be fairly challenging for some teams. In addition, the lack of project management skills seems to delay students from moving from the vision phase to realisation and causes some confusion among the teams. One solution would be that an intensive course of agile project management could be organised for second year students to secure a sufficient level of project management skills prior starting Capstone Innovation Project. Yet, it is obvious that students do not have all the knowhow needed in the projects and establishing these skills forms an integral part of the method. However, the support of our staff including project engineers in the laboratories is in some cases essential in order to guide the teams further.

Already the first pilot phase showed that assessment criteria defined in CDIO standards is difficult to apply in some projects. Especially projects which include, for example, artistic dimensions are more difficult to assess. The assessment methods and criteria need further development before the next course round starts in autumn 2014.

In addition, our internal process of finding the customers will be evaluated again after this second pilot phase. Currently, all the available topics were presented in an exhibition as discussed above. These topics were found based on our teachers’ active roles in regional development. The question is whether this is the ideal way to execute innovation projects. If students were also participating in this preliminary work they would get experience of meeting potential customers before the process started. One of the possibilities is to study how participation in this process would effect students’ commitment and motivation.

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## BIOGRAPHICAL INFORMATION

***Riikka Kulmala*** is a lecturer in Library and Information Services at Turku University of Applied Sciences. She is working as a coordinator in Capstone Innovation Project course. She has MSc in Economics from Turku University. At the moment Riikka Kulmala is preparing her doctoral dissertation in Lappeenranta University of Technology on intellectual property protection and innovation process.

***Mika Luimula*** is a principal lecturer, and Head of the Digital Media Laboratory in the Degree Programme of Information Technology at Turku University of Applied Sciences. He holds a PhD in information processing sciences and an MSc in mathematics. He is leading game development R&D activities in the Game Tech&Arts Laboratory. His research interests include game development, serious games, health informatics and location-aware systems. He has published around 50 scientific papers in the above-mentioned research areas.

***Janne Roslöf*** is a principal lecturer in Software Engineering at Turku University of Applied Sciences. He holds a D.Sc. in Process Systems Engineering and a M.Sc. in Chemical Engineering from Åbo Akademi University (Finland), and a M.A. in Education Science from University of Turku (Finland). Dr. Roslöf is head of the B.Eng. Degree Programme in Information Technology at TUAS. In addition to his daily tasks as engineering educator and administrator, he has participated in several national and international educational development projects.

***Corresponding author***

Riikka Kulmala
Turku University of Applied Sciences
Faculty of Business, ICT and Life Sciences
Joukahaisenkatu 3 C
FI-20520 Turku
Finland
riikka.kulmala@turkuamk.fi