Commencing Studies with a Project

Ville Taajamaa, Pasi Liljeberg, Tapio Salakoski

Department of Information Technology, University of Turku, Finland

Email: ville.taajamaa@utu.fi, pasi.liljeberg@utu.fi, tapio.salakoski@utu.fi

Abstract

Project–based learning was utilized starting from day one to introduce engineering to new students. In this approach lecture based course was replaced by hands–on doing in a group work environment. According to our results project– and hands–on doing based course gives higher learning results and better motivation for first year students of engineering. This paper is outlining the planning process, implementation, and the results of the first term project –course. Introduction to Engineering –course was developed to commence the bachelor level engineering studies in the University of Turku Finland. The course is a problem–based project–course for first year engineering students of IT and Biotechnology. This article is based on data from a student survey, study journals, and teaching teams documentation in addition to first hand experience of developing and managing the course.

Keywords: *Project-based Hands-on Learning, Engineering Education, Working Life Skills*

1 Introduction

"It all starts with the STAR WARS Imperial March music. You can read from the faces of the all incoming students that they are thinking "what is this..?". At 10 AM at the very first morning of their student life and study careers in becoming engineers the Introduction to Engineering course begins. It is all about doing. It is all about problem solving. It´s about doing it together. Every theory needs to be validated in practice. We believe that engineering identity is inextricably linked to problem solving. That is what we want them to learn. And they need to learn it in small teams and in a project setting. Simple as that." [teaching teams documentation]

Introduction to Engineering – Course [IEC] was one of the new courses created in the engineering education reform in the University of Turku, Finland. The reform focused both to a curriculum development as well as to improve aligning learning and teaching methods [Biggs 2003]. IEC was developed in order to give the first year students an idea about what engineering is all about starting from day one [Atman, Sheppard, Turns, Adams, Fleming, Stevens, Streveler, Smith, Miller, Leifer, Yasuhara & Lund 2010]. Originally the idea was to follow the CDIO framework [Crawley, Malmqvist, Östlund, Brodeur 2007] and start an introductory engineering course that follows the standard 4:

*"An introductory course that provides the framework for engineering practice in product and system building, and introduces essential personal and interpersonal skills."[*http://www.cdio.org/implementing-cdio/standards/12-cdio-standards#standard4*].*

Thematically IEC focused on three main themes: from theory to practice that is to hands-on doing and learning by doing philosophy, problem – based learning [Lehmann, Christensen, Du & Thrane 2006] in a project environment, and in a group work approach. Still, the basic idea of providing "an idea of engineering practice" as described in CDIO standard 4 was left intact. Product Development theory was also one of the underlying theoretical themes [Koen, Ajamian, Burkart, Clamen, Davidson, D'Amore, Elkins, Herald, Incorvia, Johnson, Karol, Seibert, Slavejkov & Wagner 2006]. Interdisciplinary issues were also discussed as the students were from both Information Technology [IT] and Biotechnology fields. The teaching team consulted other faculty as well concerning first year studies in whole, so that the curriculum for the first year would be as aligned as possible [Biggs 1996]. In the end it was decided that content wise the main areas of study would be sensor networks, cyber physical systems and basic programming skills. As in the other courses utilize Java [Gosling, McGilton 2009] the teaching team decided to use Python programming language [Guido, Drake 2003] as the learning environment for programming. We also checked the suitability of Python for programming Lego robots [Knudsen 1999] that were used to facilitate the hands-on learning process. It, however, turned out that Python could not be used for programming Lego robots. This did not hinder the course progress

through but it is something that needs to be changed for the future years. Considering that the course was implemented for the first time the result is good. It is difficult to analyze why the overall score was so good. Almost every fifth person has given it full points and 94% considered the course to be from good to really excellent. Deeper understanding of the reasons can be sought from the "Results" section where more detailed questions and answers are presented. For the 6% giving the grade 2 of which was "not good" there are two main reasons according to the study journals. Firstly the team sizes were large, up to 8 persons per team. This inhibited learning results to some extent and secondly more than 20% of the students were second or third year students changing from the old degree structure to the new one. For some of these students the motivation to commit to the course was questionable.

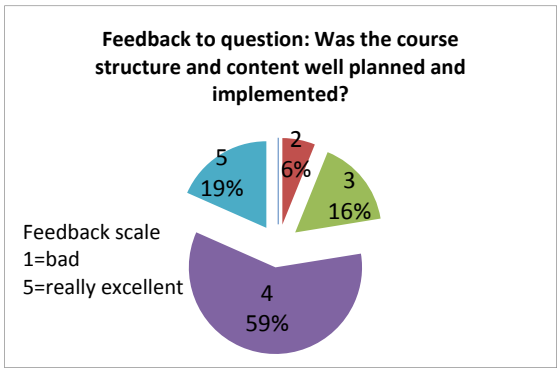

Chart 1. The overall grade for the course given by the students that participated the Introduction to Engineering –course.

2 Implementation

As for learning approach wise the Introduction to Engineering – course used and uses mainly cognitive and social constructivist approaches with emphasis on the fact that group work leads to constructive learning instead of objectivist transmission of knowledge [Biggs 1996]. The learner, student, is in the center of knowledge and meaning creation [Biggs 2003]. This is especially in the group work phase, which comprises more than half of the course workload.

In the first place the faculty curriculum development team went through the curriculum course by course for the new degree structure and outlined the Intended learning outcomes for each course. For IEC the outcomes and course guidelines depicted by the curriculum team were:

1. During the course the students will learn how to analyse, create possible solutions and implement them in multifaceted engineering problems.
2. After the course the student will have preliminary readiness for small group work in a project environment.
3. Project work will include understanding of planning phase and project management, communicating the achieved results both literally and orally.
4. The student will also learn how to manage and prioritize time planning.
5. During the course the students will have the opportunity to recognize and develop their substance learning and personalities.
6. During the course the students will learn about learning and will learn to trust her/his abilities to solve problems
7. The assignments and themes will change on a weekly basis and they will contain tasks and competitions that will develop the ability to conceive problems settings, designing and executing solutions.
8. Course will contain individual student assessments, self-assessments, building personal portfolios; for example personal strengths, work capabilities etc.
9. During the course the students will apply to different roles.

To pass the course student must pass a written exam and weekly assignments.

List 1. The original Intended Learning Outcomes for IEC course developed by the faculty curriculum development team.

Looking now retrospectively it is obvious that the aims were quite high. This was, however, impossible to predict at the planning phase of the course. According to the survey and feedback, especially the intended learning outcomes 4, 5, 10 and 11 were too far fetched [see charts]. Although these are good learning outcomes per se they are more appropriate to module or even degree level than to a one 5 ECTS course aimed for first year students.

Originally the teaching team for the planning process had six persons of which two were associate professors, three were assistant professors and one was a student representative. The team met five times during the Spring 2012 and after the first meetings the core team was one lecturer from Biotechnology, one from IT and the student representative. During the development process of the course planning, the teaching team decided to make their own version of the Intended Learning Outcomes. This proved to be very fruitful because this way the team was very committed to actually fulfil the ILO´s. The modified learning outcomes are:

- understand the engineering process
- get motivated about engineering
- to obtain comprehensive capability to solve problems
- being a part of a team (three musketeers)
- ability to tolerate uncertainty and failures
- creating time tables and prioritizing
- learning by doing

List 2. The Intended Learning Outcomes that were constructed by the IEC teaching team.

Teaching during the course concentrated on the major themes being: Learning by doing and project and problem based learning in teams. As for the substance content software and programming were much more emphasized than it was preliminary thought. The programming language was selected to be Python because it would be aligned with the other course especially for IT students. As the students for the course are comprised 80% of IT students and the rest being Biotechnology students, IT-skills have a role to play in the course content and goals as well. Furthermore, basic programming skills can be seen currently fundamental engineering skills regardless of the field of study. As for "*creating time tables and prioritizing"* the learning results were not that excellent [see chart 2].

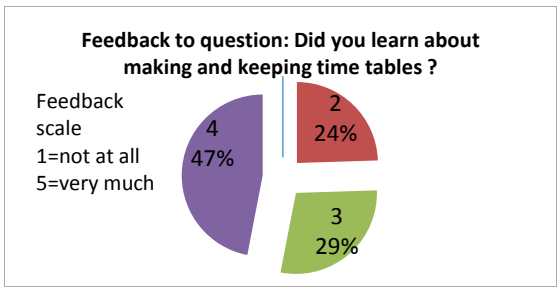

Chart 2. The learning results for scheduling on a scale from 1 to 5 five being the best.

Compared to the other result the students did not feel that they learned scheduling that much. The reasons for this can vary. Firstly this subject was not taught explicitly and secondly not much emphasis was put to scheduling in general. Question is should it be an intended learning result at all? Probably it will be left out from the course content in Fall 2013. All in all, the result of the intended learning outcome can still be regarded as good.

The course was structured and content followed the idea of introductive lectures to:

- Team building
- Human element
- Sensors in embedded systems
- Basic programming skills

The professors were from inside the University of Turku and were experts in their own fields. The teaching team responsibility was to plan the sessions and advice the expert lecturers what was expected of them and then also coach the hands-on phase of the sessions, typically in the afternoon. Hands-on teamwork part of the courses consisted of project assignments where Lego robots [Knudsen 1999] were utilized. The course lasted for the whole autumn term, every week Monday from 10 am to 2 pm. The idea was that the students would typically have lectures or presentations by professors in the morning and project based hands-on doing in teams in the afternoon. In the second

part of the term there were more and more projects that lasted the whole 4-hour session to two sessions and finally to three sessions culminating to the final competition, which was executed as a robot football tournament, see Picture 1.

Picture 1. Robot Football tournament

The Introduction to Engineering course culminated to Robot Football tournament where the teams competed for the course championship. The teams had altogether 12 hours of time to build the robots. They were two robots per team. One was a goalkeeper that was programmed and worked independently with artificial intelligence and the other was a field player that was steered remotely through bluetooth interface.

3 Results

This article is based on data from a student survey from the course, study journals of the students, and teaching teams documentation from the planning phase, during and after the course. All the students who passed the course, 70/75, answered the survey. The pass rate was more than 93%, which can be considered excellent in Finnish engineering education context [Korhonen-Yrjänheikki 2011].

The main focus of the intended learning results was on problem solving (see chart 3). Engineering is all about problem solving [Atman, Sheppard, Turns, Adams, Fleming, Stevens, Streveler, Smith, Miller, Leifer, Yasuhara & Lund 2010; Lehmann, Christensen, Du &Thrane 2008]. Conceiving the problem, designing a solution and implementing it is basic cycle of CDIO framework [Crawley, Malmqvist, Östlund, Brodeur 2007] and the same applies for IEC. Project based Problem solving in a teamwork environment can be regarded as the main process for the whole course. It is, however, important to note that more than one person out of ten felt that they did not learn problem solving. Reasons vary. Looking at the study journals the students that felt they did not learn so much were mainly second and third year students changing from an old degree structure to the new one. Still the most important fact is that more than half of the students gave the best possible grade to the learning of problem solving and 88% of the students gave the result from good to very much.

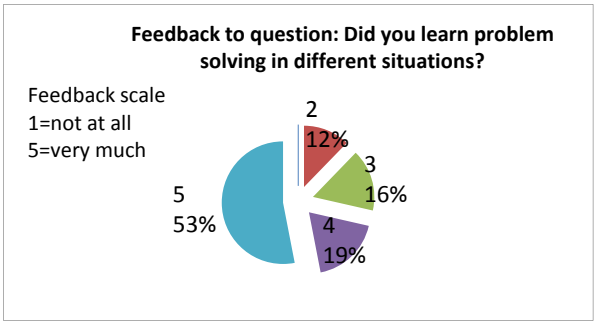

Chart 3. Results from problem solving from the IEC.

Is having fun while learning illegal? Hopefully not because:

> *"The characteristics of fun are that it is relative, situational, voluntary, and natural. Fun can have a positive effect on the learning process by inviting intrinsic motivation, suspending one's social inhibitions, reducing stress, and creating a state of relaxed alertness."[*Bisson &Luckner 1996*]*

The teaching team felt that if the students are having fun at the course this will endorse their learning and motivation [see chart 4]. Having fun can be intuitively seen as contradictory to studying and to university level studies in general but it actually engages the student to the studies and enhances learning in a deep level. Study journals shows that the students were committed to the course and that this was more than partly because it was fun to do the assignments. It is of course a challenge to the teaching team, to the planning process and to the visiting lecturers to invest their time resources in order to make cognitive processes happening. Commitment has to be both ways.

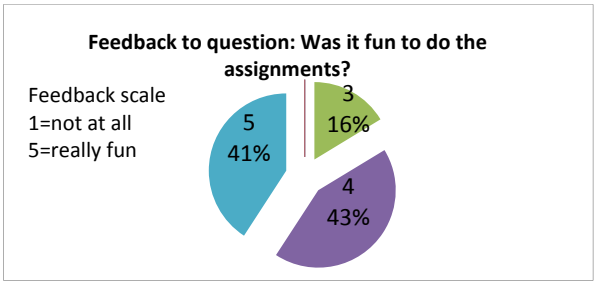

Chart 4. Having fun while learning is not illegal.

Group work or teamwork setting was originally thought to be one element of the course but not for the whole course. It, however, evolved so that during the whole course the students were in teams and actually in the same teams for the whole course. Was this good or bad is difficult to say. The teaching team discussed this a lot before and during the course and decided to monitor the progress. As the assignments got more complex in the beginning of the second term the teaching team decided not to change the formations. Considering that the teams were up to 7-8 persons the learning result is excellent [see chart 5].

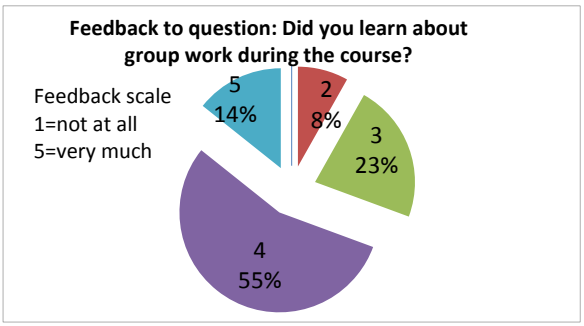

Chart 5. Group work or teamwork was one of the main learning objectives for the course.

One of the main goals, if not the main goal, for the IEC was to show what Engineering is all about and to do this in a problem and project based teamwork environment. Typically engineering degrees start with an emphasis on natural sciences such as mathematics, physics and chemistry for example. This can have a negative influence on student retention [Ulriksen, Madsen, Holmegaard 2010]. Engineering degree structure in University of Turku is not that different. It is, however, important for the students to realize why they are studying those subjects. Through an introductive course they will get an understanding what is the engineering work all about. If the students get excited about engineering and about what it will be like to work as an engineer, university has succeeded well. Not only because the student retention is high, but also because it is being honest to the students about what they will be facing later in their

working life. 94% of the students are motivated to continue their studies. In societal and institutional perspective this is perhaps the most important result of the whole course (see chart 6).

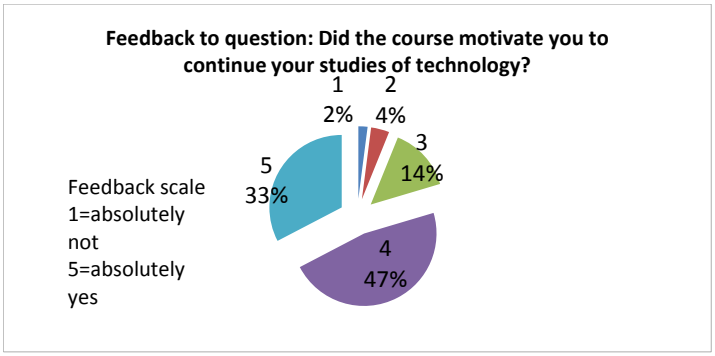

Chart 6. Student retention is one of the big issues in Engineering education. Motivation to continue ones studies after the first year is very important.

4 Discussion

We discussed in this paper the planning process, implementation, and the results of the first term project course. Introduction to Engineering which was developed to commence the bachelor level engineering studies in the University of Turku Finland. The course was structured to be a problem–based project–course for first year engineering students of IT and Biotechnology. The data for the discussion were from a student survey, study journals, and teaching teams documentation in addition to first hand experience of developing and managing the course.

According to the material of the study the main factor for the course success is that it is an action, hands-on and learning by doing – based course. Students simply appreciate the hands-on approach and the fact that they can influence the outcomes of the projects. Another factor is that the intended learning outcomes are mainly focused on generic working life skills. Although also substance issues such as sensor networks, cyber physical systems and basic programming skills are taught the focus of the intended learning outcomes is on team building, project work and hands-on doing. One important aspect is also that a lot of responsibility of the actual implementation of the assignments is on the student groups themselves. They acknowledge that they can influence their own learning results and the outcomes or their project work and the flow of the course. In a sense there is room for creativity as the end results are not decided by the teaching team beforehand.

The course evolved during the planning and implementation process. One of the main learning results for the teaching team was that, during developing a new course the team needs to be able to very actively reflect on the outcomes of each session and develop the future sessions accordingly. The final outcome, and at least the way that the course was implemented, may appear to be very different from the initial plans. In the case of IEC the Intended Learning Outcomes developed by the teaching team (see list 2) were fulfilled in many parts but the implementation of each teaching session was designed mainly after the previous session. In this way all the sessions could be aligned in order to achieve best possible learning experience and results for the students.

Planning, development and implementation of the Introduction to Engineering course was both challenging and rewarding. For the teaching point of view, three main issues are noticed a) teacher to step down from the master-student setting, b) not define all the assignment outcomes too precisely beforehand and c) work in a group teaching setting where a lot of new ideas and ways of executing the course can be found. In addition, it is also important for the continuum of the course and for the implementation of constructive alignment [Biggs 1996] to have several members of the faculty to be familiar to the structure, content and the model of executing the course. Utilizing Lego – robots proved to be very useful both in terms of learning enhancement by providing physical hands-on experience as well as for teaching the basics of embedded electronics and programming skills. The actual interface of the NXT robots is based of drag-and-drop software, which makes it easy to comprehend and use even for students that have no previous experience in software engineering. In terms of project and group work setting the biggest challenges lie on the circulation of teamwork roles, assessment of the teamwork and project outcomes. Teamwork setting is a challenge to any student group, especially to first year students and the assessment and grading are difficult. One very important aspect of engineering work, that is, engineering ethics was dealt only superficially during the course. There is much room to improve in that [Heikkerö 2012]. All things considered the first Introduction to Engineering –course was a success. Hands–on approach with emphasis on problem solving and teamwork have given the students an

empowering feeling, student retention at the course was excellent and the clear majority wants to continue eagerly their engineering studies after the course. Also the overall grade the course given by the students suggests that the practical steps of the reform process are going to the right direction. And let´s not forget that it all has to be fun as well.

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