

Interdisciplinary Capstone Project

V. Taajamaa

Project Manager
University of Turku
Turku, Finland
E-mail: ville.taajamaa@utu.fi

T. Westerlund

Associate Professor
University of Turku
Turku, Finland
E-mail: tomi.westerlund@utu.fi

P. Liljeberg

Associate Professor
University of Turku
Turku, Finland
E-mail: pasi.liljeberg@utu.fi

T. Salakoski

Vice Dean / Head of Department
University of Turku
Turku, Finland
E-mail: tapio.salakoski@utu.fi

Conference Key Areas: Industry and engineering education, New learning concepts for engineering education, Student as key actor in change process of engineering education

Keywords: Engineering Education, Project based learning, Interdisciplinary learning

1 INTRODUCTION

This paper presents the planning process, structure and first results of an international and interdisciplinary master's level Capstone –project course carried out in collaboration with University of Turku, Finland (UTU), Hewlett Packard Europe (HP) and Fudan University PRC (Fudan). First the background, structure and planning process of the actual course structure with the Intended Learning Outcomes (ILO) are presented after which the case study is analyzed using course material including study journals and documents from the weekly student seminars. By analyzing the forming phase of the project and decision making from different

stakeholders point of view a holistic postulation of the course concept can be made. This will also promote further the development of the course and engineering education structures in general in the case university.

University of Turku is a multidisciplinary science university. It is the second largest university in Finland and the largest that has engineering education. Engineering Education has a special role as integrating the different disciplines of the University. Especially in it's master's level studies.

UTU has been going through an extensive engineering education reform process since the end of 2011. The whole bachelor and masters level curriculum is reformed. The main emphasis is on both reforming structures as well as adapting new ways of educating the students. Bologna process [1], social constructivism [2] and problem based learning [3] are important guidelines in the development process. The overall aim is to a) integrate more working life skills into the curriculum and b) give the engineering education in UTU a clear international and interdisciplinary profile [4]. These goals are co-created together with faculty and students and partly with the industry and academia in Finland. Also a benchmarking of different engineering education theories and practices were done [5, 4, 6]. Reasoning behind this is that in Finland the engineering students have excellent in-depth knowledge of science and technology [7,8]. However, entrepreneurial, communication, interpersonal and teamwork skills on the other hand need to be developed [7,8].

"I have come to think that the whole point of the course is this: we start believing in ourselves. It is essential when entering the "adult world", the real working life." A student from HP capstone team

The capstone-project concept is an important part of this process. This is where the students will receive their interdisciplinary experience while they work in a teamwork setting and solve ill-defined problems coached by the teachers. To commit the key stakeholders to a capstone project is essential; otherwise there is a potential risk that the whole project will fail. In [9], reported challenges in finding faculty members in university to mentor capstone projects. Faculty members were committed only to those capstone projects that supported somehow their research. In [10], the authors described several challenges from which the most common one is coordinating the schedules of academic faculty. They also mention that the commitment of students to the projects is difficult. This was also a challenge in another Capstone project in UTU.

Especially in IT, there is an on-going development process "Engineer meets Human" where the goal is to integrate the key strengths of the multidisciplinary university into the engineering education such as Health and Wellbeing, Educational Technology, Business and East-Asian Studies (Global Information Society). This is done by introducing thematic multidisciplinary profiles from UTU's excellence areas to the curricula of the engineering education. Integration of multidisciplinary thinking and courses into the engineering studies is done in both the bachelor as well as in the master's level [4].

2 METHODS

This research is carried out during the implementation of a capstone project. The data is gathered from study journals, feedback surveys and proactive working-life

simulated development discussions. Questions concentrated on team-building, personal development, work environment, interdisciplinary learning, cross-cultural learning, opportunities and challenges of the project etc. The main goal of the feedback and data gathering is a) to help the course structure and procedure development in the future, b) assessment tool for students performance assessments and c) validating the outcomes of the Engineering Education reform success. Data is gathered from all of the team members at different stages of the project.

3 INDUSTRY COLLABORATION

Industry collaboration has been a natural part of our department's practices since the 1980's. It has been present at several levels from industry funded projects to master's thesis works. The common issue among these collaboration forms is that they all concentrated to the core competence of the department: software and computer engineering. Project teams were one discipline teams, and thus team members from other disciplines were nonexistent. This means that the potential of a multidisciplinary university was not fully utilised. During the curriculum reform, interdisciplinary approach was strongly present throughout the process. It is an essential part also of the HP capstone project. The biggest gain for HP is the fact that the students from different disciplines will look at the project from a very fresh point of view. They are young enough to think they can do and achieve anything, even the impossible. This kind of attitude, with the right kind of coaching, aims to give thrust of energy and "out-of-the-box" thinking to the project and to achieving its goals.

Then again looking from an university point of view in UTU the situation is very good for this kind of new interdisciplinary course concept because it has started to integrate also other than just technology and business disciplines into the Master's level studies. Since UTU, and FUDAN as well, are comprehensive science universities, they can utilise in-house expertise to get all the knowhow and resources they desire. This is both challenging and rewarding. It also brings the international and multicultural perspective as there is the possibility of making project as Sino-Finnish/Nordic level. This poses a great interest for both partners.

Then why do we do these? Hopefully because of the students and the learning outcomes they receive. From the students perspective the idea is that they receive real-life experiences working with open-ended and ill-defined problems in a project and teamwork based setting. The Intended Learning Outcomes for the Capstone project were originally made for the engineering degree and engineering students but they apply for students from other disciplines as well. The results for student learning are presented in a SWOT analysis in "Results" section.

After the course the participant is expected to be able to:

- 1 Analyse technical problems in a *systems view*
- 2 Analyse and solve technical problems which are *incompletely stated* and develop iterative strategies subject to multiple constraints
- 3 Develop strategies for *systematic choice and use of available engineering methods and tools*
- 4 *Make estimations* and appreciate their value and limitations
- 5 *Make decisions* based on acquired knowledge
- 6 *Pursue own ideas and realise* them practically

- 7 Assess *quality of own work* and work by others
- 8 Work in a true *project setting* that effectively utilises available resources and applies good timely project management practices
- 9 Explain mechanisms and processes behind progress and difficulties in projects
- 10 *Communicate engineering in a interdisciplinary environment to different stakeholders* – orally, in writing and graphically

List 1. Intended Learning Outcomes for the Capstone–project. The outcomes are applicable to other disciplines as well.

3.1 Results

A basic SWOT analysis is used to elaborate the learning results of the Capstone project from the students perspective.

Strengths: Interdisciplinary aspect is experienced to bring a considerable amount of new learning to the team members. They explicitly acknowledge that they have gained insight from the different disciplines and from the teamwork setting. Another strength is that the coaching mentality instead of transmitting knowledge approach is appreciated by the students.

Teamwork

“During my years in university life, I haven’t done much group work at all. Whenever some group work has been involved, I have found it more of a nuisance than a good way of learning. To be honest, before this I have never enjoyed or benefited from university group work.”

I have very much enjoyed working with our group, although at times it has been very inefficient. I have learned A LOT from the other members and they have made me think very differently about a lot of issues – and only two months have passed by!”
Student 1

“Students in the early courses I have taken were mostly students from the same faculty, or have quite the same educational background. Those top students were easy to become the “leader” of the collaboration, and other students voice would be hard to hear.

Whereas in this course, everyone is having responsible and freedom to organize our rules and roles and cooperation freely. We can share things as we decide ourselves. Mostly this has been working well and all have done those things which we together have decided.” Student 2

Role of the teacher

“The role of the teacher is more similar to a coach that enables and supports the execution of the project. On the other hand, he is not part of the team, but at the same time participates actively in the discussion and engages on the project planning process in more general level. If one considers typical university teachers, they are more remote and hold certain distance to the students. Moreover, the role of the

teachers is to provide certain information and knowledge for students, but the project teacher offers more tools to gain information and optional approaches to the topic of the project.” Student 3

“The teacher elaborates and summarizes the project members’ opinion in a very concise manner, which guided us to move forward. He does not tell us what to do, which is very frustrating for Asian students in general.” Student 4

Weaknesses

The team has members from two continents, many of the students have part-time jobs, they have personal life or study constraints and other interests. All this leads to the fact that the team members do not have enough time to allocate to the project. This influences their learning as well. There are two different types of answers to the questions which are the goal of the course (1) and what is the goal of the project (2). In a) part of the answers the student has been able to participate to the course actively and in cases b) they have not been able to do that. Both are on the right track but at least the communication is not as active. It is more than possible that the learning results are different as well.

1) What is the goal of the course in your own words

a) On my opinion the goal of the course is to learn skills required in working life, such as project management, team working and problem solving. In addition, during the course students are encouraged to find ways to combine their academic knowledge to a more practice orientated problem solving. Students should learn to gather knowledge, create different estimates based on the knowledge, estimate different options and make informed decisions. However, at the same time, they should be able to change the course of taken actions and be prepared to operate in changing environment. Moreover, I would state that an important aim is to encourage students to get familiar with other disciplineries academic research topics.

b) Try to think from customers side, work as a team member and learn to work with different countries and backgrounds.

2) What is the goal of the project in your own words.

a) I find the project to have two different important goals. One is to produce high-quality research that has a down-to-earth approach to the research topic in hand. Secondly, an important goal is to meet main sponsor’s expectations on the project results. Here, the aim is to build as realistic as possible process, which is similar to open-ended projects in working life with time constraints and customer demands.

b) Find the potential market for HP calculators and make a good prototype.

All this said it is important to remember that most probably all of these constraints will be found in the working life as well. So, actually, the students are practising how to deal with real-life constraints.

From the perspective of the teaching team the main weakness is the lack of knowledge transfer. The course should have at least assistants in addition to the responsible teacher that follow and manage the course constantly so that the development of the course could be secured.

Opportunities

If rightly utilised the interdisciplinary Capstone–course setting does provide important learning possibilities for both students and teachers. It also enhances the students working life readiness as the student learns working life skills during studies. In HP-Capstone project the industry benefits are yet to be actualized but the chances for concrete and pragmatic results are there.

Threats

One single biggest threat is that the teams effort and practical work will dilute because of the constraints such as: different interests, different skill sets and knowledge, lack of communication, personal life, working commitments such as internships, lack of coaching and mentoring or cultural differences to mention a few. It is also unclear how the assessment and rewarding is done both in UTU as well as in Fudan. Looking from the students perspective this is of paramount importance. The teaching team consist of several teachers but is basically depended on the course management done by the responsible teacher. Knowledge transfer is not as flexible and active as it should be.

4 DISCUSSION

The engineering education reform and planning phase of new curriculum, teaching and learning methods in the University of Turku offered a structural and a co-operative approach to the creation of the Capstone – project course. As a result of this it was straightforward to communicate this also to the potential industrial partners in a cooperative and co–creative way. Once the key ideas, objectives and constraints of the project course were shared the co–operative tailoring with the industrial partner of the course pragmatics in the case example was relatively easy to do. In this way it was secured that all the stakeholders understand the final aims and outcomes of the project to all parties. Interdisciplinary character of the course and in the project student team brings both added value and added challenges. Explicit structuring, active and reflective developing mode for all stakeholders including the students is of paramount importance. Especially the teaching team needs to be able to take into consideration the Intended Learning Outcomes for all the students. One challenge is that the students come from different disciplines with different degree structures. How to assess and for example reward study points can be one of the pragmatic problems.

One of the most important factors to communicate clearly to all of the stakeholders is that the most important outcome of the Capstone project are the learning results. This means that even though the project aims for high output and results for the project customer if there is contradiction between learning results and output then the learning results always comes first. This is very important to make explicit to all of the stakeholders as was done in this project.

One disclaimer though: in these kind of projects we are going into "unknown waters" with the students. Nobody knows what are the outcomes. We cannot simulate, we need to DO. The learning curve will be high for students as well as for coaches, and hopefully for the HP people involved as well. We aim to get both high end and innovative results for HP as well as very thorough and deep learning for our students. But if we need to choose, we are satisfied with great learning results for our students. This is the way it goes.

source: Capstone teaching team email to all of the stakeholders: Hewlett Packard, FUDAN and UTU administration before the start of the project to elaborate the course philosophy.

At the moment UTU does not yet have a solid structure nor procedure for managing the capstone-courses: who has development authority and with which resources, at which point of the project is there different courses etc. Having clearly defined Intended Learning Outcomes is a good start but they do not answer the most important question: how to achieve them? And also how much is there room for tailoring each project and how standardised are they? All of these questions are yet at least partly unanswered. So the management process and the structure with all the needed courses: team-building, project leadership, and discipline specific are still in the developing phase. But is this a bad thing? If the whole purpose of the capstone is learning-by-doing and hands-on approach, then the actual course development should be done in the same way? So “practice what you preach”. Best practises and experiences need to be developed from experience and this takes time. For example the choice not to have a project manager in one of the projects was one of the reasons for failure in the team communication. All this also affects the industry and university collaboration. Even though in abstract level the structure and process of Capstone is comprehensible and easy to communicate the actual implementation is another thing. And how to standardise this is yet to defined. If it is even possible. All this said, the preliminary results support having interdisciplinary Capstone projects and the fact that the students learn relevant working-life-skills. Even from the ones that seem as failures in terms of actual project results.

“Education is an admirable thing, but it is well to remember from time to time that nothing worth knowing can be taught..”

Oscar Wilde

5 REFERENCES

- [1] EU (2011), Recent developments in European higher education systems, European Commission staff working document (SEC (2011) 1063 final) 20 September 2011
- [2] Biggs, J., (2003), Aligning teaching for constructive learning, The Higher Education Academy
- [3] Lehmann, M., Christensen, P., Du, X., and Thrane, M., (2008) Problem-orientated and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education, European Journal of Engineering Education, Vol.33, No. 3, June 2008, 283-295
- [4] Taajamaa, V., Vilonen, K., (2012) Future trends of engineering education – implementing CDIO, ICEE 2012 conference, Turku Finland
- [5] Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R., (2007) Rethinking engineering education, The CDIO approach, Springer, 286 pages.

- [6] Atman, Cynthia J., Sheri D. Sheppard, Jennifer Turns, Robin S. Adams, Lorraine N. Fleming, Reed Stevens, Ruth A. Streveler, Karl A. Smith, Ronald L. Miller, Larry J. Leifer, Ken Yasuhara, and Dennis Lund. (2010) Enabling Engineering Student Success: The Final Report for the Center for the Advancement of Engineering Education. San Rafael, CA: Morgan & Claypool Publishers

- [7] Crawley, E., Grant, D., (2012), Achieving excellence in engineering education: the ingredients of successful change, The Royal Academy of Engineering, 3 Carlton House Terrace, London SW1Y 5DG

- [8] Mielityinen, I., (2010) "Finland needs to educate world-class engineers", Annual SEFI Conference 2010, <http://www.sefi.be/wp-content/papers2010/papers/1181.pdf>

- [9] Kathleen A. Phillips, Helen J. Doyle; An interdisciplinary capstone experience integrates science, technology, business, and law for joint MS students in environment and resources at Stanford University; Journal of Environmental Studies and Sciences; September 2011, Volume 1, Issue 3, pp 201-20

- [10] Philip Camill, Kathleen Phillips; Capstones and practica in environmental studies and sciences programs: rationale and lessons learned; Journal of Environmental Studies and Sciences; September 2011, Volume 1, Issue 3, pp 181-188