SUSTAINING CDIO ELEMENTS IN AN INSTITUTIONAL RESTRUCTURING PROCESS

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ABSTRACT

As in many other countries, the Finnish higher education has experienced a significant development phase during the past few years, and this change process still continues. The drivers behind the structural development include both elements aiming at enhancing the quality of education on several planes but clear requirements to improve in terms of economic efficiency are present, too. One concrete indicator illustrating the level of economical steering is the fact that the annual governmental funding of the Finnish universities of applied sciences will be stepwise decreased by roughly 15% between 2012 and 2016.

In this paper, the curricular reform of the Bachelor's level engineering education in Information and Communications Technology related programs at Turku University of Applied Sciences (TUAS) will be discussed. Special focus is set on describing the challenges considering sustaining and further developing of the CDIO-based elements in the new curriculum and the department's operational structure. The main goal of the paper is to provide a case study documenting a major curricular change process, and to discuss it from different perspectives with peers of the international engineering education community.

KEYWORDS

Change Management, Curriculum, ICT, Standards: 1, 3, and 12 (also others)

INTRODUCTION

Finnish higher education has experienced a significant development phase during the past few years, and this change process still continues. The drivers behind the structural development include both elements aiming at improving the quality of education but clear requirements to be able to improve in terms of economic efficiency are present, too. The long period of economic downturn and its pressure to public spending in, for example, Finland has led to major cuts in the resources throughout the different parts of the education system. One concrete indicator illustrating the level of economical steering is the fact that the annual governmental funding of the universities of applied sciences, including TUAS, will be stepwise decreased by roughly 15% between 2012 and 2016.

In practice, these financial cuts have affected the resources invested in teaching and learning activities significantly more than the overall figures indicate. It is difficult, if not impossible, to

adapt the cost structure of a major higher education institution to significant changes in the incomes evenly during a rather short period of time. That is, the fixed costs bound, for example, to different facilities generate an even more significant need to cut the short-term personnel costs. Accordingly, this has caused a requirement to rethink also the TUAS internal structures and processes on all levels. On departmental level, this adaptation has resulted in not only direct layoffs of both faculty and other staff members, but also in restructuring of the degree programs in general, and in reforming of the curricula as well as ways of organizing the daily activities in particular.

Partly regardless to the drivers behind this type of processes, a significant reform is always an opportunity to conceive novel and innovative structures and ways of working. Yet, when an educational institute faces economically challenging times, there is also a risk of losing many of the earlier advances in the development of active learning and teaching methods, for example. If there is a de facto need to cut the program-level spending by approximately 30% within a few years' timeframe, how shall the operations be organized? It is impossible to plan and implement the activities "as before". To quote a colleague's recent statement "will the last teacher standing simply turn off the lights", or is there a possibility for yet another rise of the phoenix?

In this paper, the curricular reform of the Bachelor's level engineering education in Information and Communications Technology (ICT) related programs at TUAS is discussed. Special focus is set on describing the challenges considering sustaining and further developing of the CDIO-based elements in the new curriculum and the department's operational structure. The planning process and its main challenges will be explained and illustrated. Finally, the main parts of the new curriculum will be presented, and certain practical perspectives to the future implementation of the curriculum will be reflected. The main goal of the paper is to provide a case study documenting a major curricular change process, and to discuss it from different perspectives with peers of the international engineering education community.

BACKGROUND

The restructuring process of TUAS includes, obviously, several different dimensions, and adaptation to the new operational environment is still ongoing. Yet, this paper does focus neither on the general change management flavors, human resource challenges nor on the analysis of eventual longer-perspective impacts of the quantitative or qualitative results caused by the process. Instead, this is a description of the curriculum reform of the B.Eng. in ICT education at TUAS implemented as one part of the institution-level changes.

From the beginning of 2000's, this education was organized as four different degree programs:

- Degree Program in Electronics (Turku campus)
- Degree Program in Information Technology (Turku campus, International)
- Degree Program in Information Technology (Turku campus)
- Degree Program in Information Technology (Salo campus)

The Degree Program in Electronics focused on hardware related topics especially on Electronics Design, RF Engineering, and Telecommunication Systems. The Degree Program in Information Technology in Salo campus focused on Embedded Systems and Software

Engineering. Furthermore, the Degree Programs in Information Technology in Turku campus focused on Internet Technology (international program), as well as Digital Media (later Game Development), Health Informatics and Embedded Software (Finnish program). The annual intake to these programs was more than 250 students at its maximum. All the programs were originally also independent organizational units with dedicated management and faculty members.

The curriculums of the different degree programs contained certain similar structures and courses, but also significant differences. These differences contained, naturally, subject-specific topics but also many methodological solutions had been designed differently. For example, all the programs had been using the CDIO principles (CDIO, 2010) as one of the main guidelines in their internal development but their implementations of the first-year introduction to engineering course were very different. Moreover, the traditions of integrating different design-implement experiences into the courses, and organizing the work placement arrangements as well as the thesis process were surprisingly different although all the programs and departments were still following the same university-level processes and guidelines. – Yet, the intention here is not to claim that one of the solutions would have been clearly better than the others but rather to illustrate that the fact that the starting point was, in practice, four different entities both in terms of content and culture. All the units had invested significant resources in developing their curricula, course implementations and learning environments for years.

The first step of the series of changes was, in fact, made already prior to the national-wide financial cuts. The program operating in the city of Salo was decided to be closed already 2008. The final intake to the program was made autumn 2009 and, today, the exit phase can be considered complete. In January 2015, there were still two students enrolled into this program. The main reasons behind the exit of the program were connected to the fact that the number of applicants had steadily decreased several years a row which was, at least partly, explained by the downturn of the ICT-based industry in the Salo region.

More recently, it was decided that the future engineering education in ICT would be organized as one degree program with an intake of 150 students to the Finnish and 40 students to the international program. The goal was to create one common curriculum starting from the autumn 2014 intake and, in addition, to organize the operations connected to all ICT-related education and research at TUAS in one organizational unit starting from the beginning of 2015. In addition to ICT engineering education, this new unit will be responsible for ICT-focused B.BA. education as well but this thread is not discussed in this paper in further details.

GOALS, CHALLENGES AND PROCESS OF THE NEW CURRICULUM DESIGN

One of the first steps in the curriculum design process was to analyze the future trends of the ICT engineering field in the industrial advisory board of TUAS. This discussion was followed by a series of seminars and meetings with the staff and, especially, senior faculty members in the ICT-related fields. The following goals were set for the new curriculum structure and contents:

- The future competence requirements of the ICT engineering graduates should be met considering, especially, the need of the industry and other organizations in Turku region.

- The curriculum structure shall support utilization of active learning and teaching methods including different ways to integrate research and development activities to the studies.

- The central CDIO elements including, for example, the introduction to engineering course and an advanced capstone project shall be included.

- The curriculum structure shall be modular in order to support further development of the content without needing to redesign the entire curriculum.

- The result should be a clear but flexible model serving the entire ICT-focused engineering education at TUAS. That is, all the new students enter the same program within which they then have the opportunity to specialize as their studies proceed.

As already described, the underlying degree programs had been used to rather independent ways of operation and they had been able to tailor their curriculum to a great extent according to their needs. Obviously, this background combined to the goals set for the new curriculum – keeping in mind the economic constraints present – led to a set of challenges during the process. These challenges included, at least, the following:

- How should the curriculum be structured: The first academic year(s) [one input] should serve the needs of all competence tracks [majors] [several outputs]?

- Which competence tracks should be included? There should be clearly less tracks than the total number of outputs in the old programs' curricula in order create larger and stronger laboratory units.

- How shall the different modules, including the CDIO elements, be defined and implemented according to high quality standards but more cost efficiently than before?

These goals and challenges strongly constrained the curriculum design process and the discussions were very lively. The process was organized by arranging a set of seminars starting from the competence requirement definitions and thereafter progressing towards the more detailed learning outcome definitions and course structures. Teacher teams worked between the seminars with selected parts of the curriculum and the overall solution was iterated further during the seminar workshops. The industrial advisory board was included especially in defining the future competence tracks.

All the underlying degree programs had worked with educational development, and also CDIO, for several years and most of the faculty members had participated in similar development previously. In addition, embedding elements providing and enhancing the professional engineering context (Crawley et al., 2008) in different parts of the curriculum was familiar to the teachers. For example, the capstone innovation project had been introduced into most of the older curriculums already some years ago as a part of the CDIO adaptation of the programs. That is, this reform could be have seen as the next natural step in the development of the curricula inspired by the CDIO principles and syllabus.

I worked as the coordinator of the process and I my personal reflections of the task can be summarized as complex. The different alternatives were thoroughly discussed but it was not an easy path to find a solution that would have satisfied many of the participants – not during or immediately after the process at least. Even though there was a rather good consensus concerning the vision of the new curriculum, there was a limited source of enthusiasm and positive development energy present. As the change process was tightly coupled to the

financial cuts, the discussions turned often to defensive paths. Which of the [or whose] existing courses would "survive" and which would not? For instance, removal of the Capstone project was proposed several times because its presence was said to block more important content from the curriculum. Although the work slowly progressed, it felt many times that some of the sceptic discussion topics we had experienced ten years ago – when the first contact to CDIO took place – had returned.

RESULTS

The final structure and core courses of the curriculum were set during autumn 2013, and the more detailed descriptions were produced after that. The overall curriculum design is illustrated in Figure 1 and a detailed description of it (including the competence definitions, yearly themes, competence matrix, course structures, learning outcomes etc.) is available electronically in the curriculum database of TUAS (TUAS, 2014).
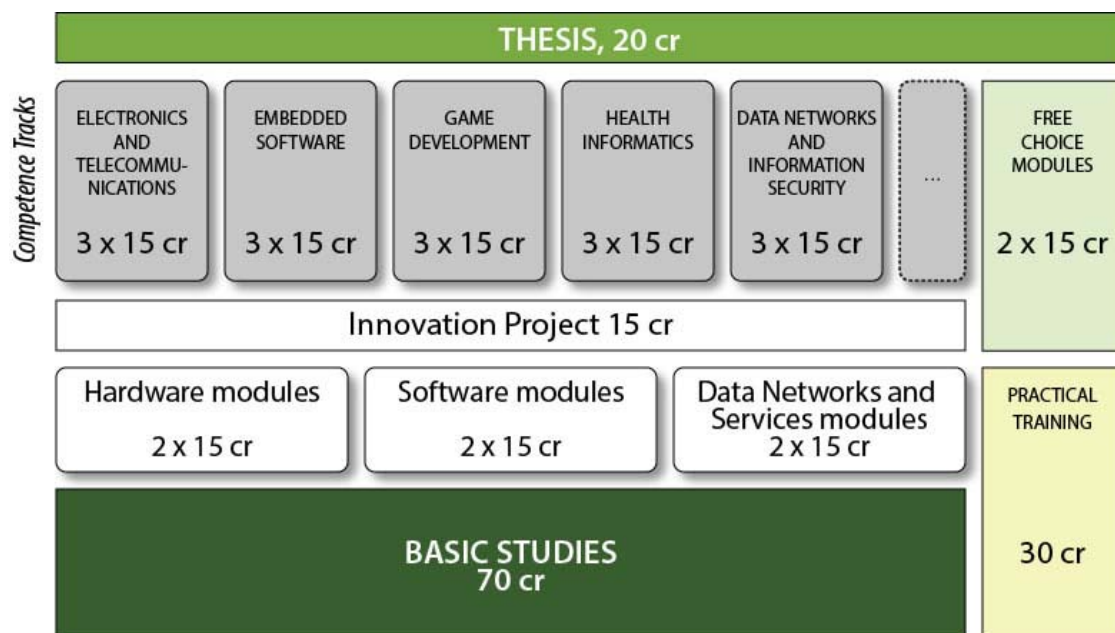

Figure 1. TUAS B.Eng. in Information and Communications Technology curriculum 2014. The total extent of the studies is 240 ECTS credits (cr).

The curriculum structure includes the following parts:

- All incoming students study the same courses during the first academic year. These courses include, for example, introductory topics in Communication Skills, Electronics, Mathematics and Physics, Network Technologies, Programming as well as the CDIO "Introduction to Engineering" course.

- During the second academic year the students can select a module of free choice studies, and an optional set of modules focusing on either Hardware, Software of Networking-related topics. The selections made during the second year constrain the students' options in the final part of their studies.

- The third and fourth academic year focus on the so called Competence Track [major] that the students select after their second year. In addition, the final two years include another module of free choice studies, a capstone innovation project during the third year, and a Bachelor's Thesis.

- Furthermore, the curriculum contains mandatory practical training (work placement; as required by the Finnish legislation) which is planned to be completed in three parts as the studies proceed.

The curriculum contains five fixed competence tracks and a possibility to tailor a unique student specific track. Unique tracks could be defined, for example, to students who participate in international exchange, start their own business ventures already during their studies, or are interested in focusing the final part of their studies to a more specific field. In addition, the structure allows updating its parts separately without been directly forced to change the larger view (there are couplings within the between the different parts of the curriculum, though).

The CDIO introduction to engineering course is implemented as a course of Product Development (10 ECTS credits) that is studied during the first academic year. In short, the course introduces the students to a new product development process, teamwork and provides the first design-implement experience. The course idea is based on further developed version of the one presented by Roslöf (2008). The CDIO capstone innovation project (15 ECTS credits) takes place during the third year and will be implemented jointly with the other programs of the faculty enabling multidisciplinary project assignments and teams. A recent description of the capstone project course implementation model that is the basis of the one selected to this curriculum can be found in Kulmala, Luimula and Roslöf (2014). The new curriculum may enable a more goal-oriented development of the CDIO-connected courses than the earlier more subject-specific curriculums. There will be a significant amount of both faculty and students participating these course modules in the future which could also improve the regional impact and industrial connections of the capstone projects.

The new students (190 students in total) started their studies according to this curriculum autumn 2014. It seems that the studies have started rather smoothly, yet the first-time implementation has created a significant amount of additional workload. Also the daily practices will, most probably, seek their ways for some time still. Currently, the fact that the different student cohorts follow different curricula and, in fact, study in a collection of related but yet different degree programs complicates the daily operations. For example, practical collisions in facility and staff resource utilizations were not completely avoided – not to forget that there is a requirement to implement everything with less faculty resources.

Additional experiences on the design will be gained as the new student cohort proceeds in the studies. One relevant flavor to be realized and planned in more detail is the different selection phases connected to the second and third/fourth year studies. It will be interesting to see how the students select, for example, the second year modules. Will there be a properly-balanced flow of students to all the tracks or will a program-internal selection process of some kind be required? The recent experiences with the fist cohort following the curriculum indicate that at least minor tuning of the selection process and its instructions is needed.

CONCLUSIONS

In this paper, the curricular reform of the Bachelor's level engineering education in Information and Communications Technology related programs at TUAS was discussed. It was described how the reform of the curriculum including a consolidation of four former degree programs into one joint structure. The goals and challenges of the process, mainly connected to simultaneous financial reductions, were summarized, and the main structure and contents of the resulting curriculum was illustrated.

One of the goals of the curriculum design was to sustain and to further develop the central CDIO-elements. That is, also the new curriculum contains an introduction to Engineering course, a Capstone project course and other design-implement elements, too. In fact, these parts are now more clearly present in the core curriculum than before and their alignment to the other courses seems better designed than before. This result required clear definition of the goals and committed support by the management. Yet, as the process included removal of several traditional courses as well as major redesign of many others, many senior faculty members did not give their support to the changes in the first place.

Although the curriculum design process and the other, partly still ongoing, changes connected to the general restructuring of the university were neither simple nor easy to manage, there are several positive threads, too. In addition to the improved role and visibility of the CDIO elements, the rethinking of the entire curriculum was certainly needed. The new structure is clearer and the different parts of the curriculum are better linked than before. Furthermore, the student has even greater possibilities to tailor his/her studies within the program and these options are easier to communicate. Time will tell how the first full implementation round of the new curriculum will be experienced, and which benefits and pitfalls will be found. Yet, the curriculum must be a living thing that follows the state-of-the-art development of the disciplines and pedagogical solutions. Also this curriculum in its current form will be outdated rather sooner than later. Let's hope that the next major reform can be performed during an economically more positive time enabling the critical success factors for sustainable educational reform (Malmqvist et al., 2010) to be more evenly balanced.

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BIOGRAPHICAL INFORMATION

Janne Roslöf, is a Head of Education and Research (ICT) 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 from University of Turku (Finland). In addition to his daily tasks as educator and higher education administrator, he has participated in several national and international educational development assignments. For example, he is a member of the national engineering education working group of the Rectors' Conference of Finnish Universities of Applied Sciences, as well as the coordinator of its ICT Engineering core group.

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