CHALLENGES IN IMPLEMENTING CDIO IN ALL ENGINEERING EDUCATION PROGRAMMES

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ABSTRACT

The paper discusses the first steps in introducing the CDIO approach in Bachelor level Engineering Education at Helsinki Metropolia University of Applied Sciences. All engineering programmes of the university are committed in implementing new curricula that are based on the CDIO principles including introductory and capstone projects and integration of courses in the form of a 10-weeks-long study modules. The motivation of adapting the CDIO pedagogy is raised from the needs of the engineering students but also from the chances of the working life. An evaluation of the current situation at the institution was carried out in the spring 2009. The evaluation was based on framework of the twelve standards of CDIO. Further development activities will be justified on the results of the self-evaluation.

KEYWORDS

self-evaluation, implementation, CDIO, commitment of the management

INTRODUCTION

This paper describes how we are aiming to employ the CDIO approach itself to facilitate the changes to all engineering education programmes of the institution. We describe how the implementation process was started and which strategies were adopted to overcome resistance within the institution.

In a conference on CDIO, there should be no need to convince the audience about current concerns over engineering education. However, there are many issues associated with the introduction of necessary changes to the practices of engineering education and in such a way that these might be solved through the implementation of the CDIO scheme. The CDIO approach can be used to facilitate the changes to all engineering education programmes of the institution.

Helsinki Metropolia University of Applied Sciences is a recently created institution (August 2008), a result of a merger between two former polytechnics in the Helsinki Metropolitan area. This merger is forcing us to re-think the whole organization from the perspective of our educational programmes and their management. Also, the merger gives us a unique opportunity to reflect-on and to adapt much deeper changes. These could raise major challenges. Nevertheless, we consider the ultimate benefits to be worth of the necessary efforts.

Helsinki Metropolia University of Applied Sciences entitles seven schools; three of them concerning engineering education: School of Information and Communication Technology, School of Industrial Engineering, and School of Civil Engineering and Building Services. 7000 engineering students are enrolled into 20 degree programmes. 700 of them are studying and working full-time in industry.

The CDIO implementation process was started year ago (spring 2008) when new curricula were created for all engineering programmes. Also, it was discussed, which strategies should be adopted to overcome a potential resistance within the institution. In doing this we also recognise that the issues being faced by us are far from unique and in fact have a much wider relevance.

The main objectives that will be addressed in the implementation project are:

- Start the process with a self-evaluation of all our engineering programmes to identify from the present situation (a) the greatest success factors that already exist and might be used in the future, as well as (b) the largest development needs in comparison with the CDIO criteria;
- Establish and develop, with the visible support of top management, a “change agent” network inside the organization to support the necessary changes;
- Begin to collect information systemically and analyze the outcomes of the process as it progresses;
- Plan how to continue with these important and necessary changes.

We all recognize that there are many issues to be addressed in order to improve engineering education. However, recognizing an inevitable change in the issues is one thing, but to achieve such a change is a different story. By introducing and sharing these themes we place our hopes on generating discussion and getting feedback at the conference.

The initial steps into the CDIO collaboration were taken in a SEFI conference some years ago where a presentation of CDIO approach was given. After that two principal lecturers, who were studying engineering education pedagogy, were asked to write their “thesis work” about the implementation of best practices of engineering education, including CDIO approach, and how to introduce them in Helsinki Metropolia UAS.

The thesis work resulted in a Finnish guidebook, an easy introduction, which can be easily handed out to all faculty and staff and even to students. The guidebook was widely distributed in the occasion of the first internal CDIO workshop held in June 2008. In that workshop more experienced CDIO users from Gothenburg, Stockholm and Turku were presenting their ideas and thus contributed to our internal discussions.

It was highly salient in that stage that we decided to create “our own way”, called “engineering education of great spirit”. All the experience and good practices will be gathered together under the umbrella of “Metropolia engineering education” and the criteria of CDIO will be used as a tool to execute the work. The already used PBL (Project Based Learning) Learning) and TPL (Total Project Learning) are actually promoting perfectly the objectives of the same framework – and the combination will be suitable for us.

As a next step we have decided to gather the already existing experience by a self-evaluation using the criteria of CDIO. That work started with a one day internal seminar, additionally highlighting the importance of making decisions for our next development actions. The self-evaluation helped us to find out criteria by criteria if is it relevant for us and where do we stand on the general level of the CDIO norms. Defining the target status and the gap to the target gives us tools to prioritize the coming actions.

CURRENT CONCERNS OVER ENGINEERING EDUCATION

Attractiveness of engineering studies

In many OECD countries, many post-secondary students not only find the profession of an engineer attractive, but also are not inspired by its challenges. Although the degree requires hard work to be accomplished, it is not seen as leading to senior positions, significant financial remuneration, not to mention a secure stable employment. Furthermore, engineering has more of a reputation for creating rather than solving problems. That is somewhat better in Finland, as engineering education continues to be well appreciated, and engineers are hired to many new areas of work, as they are expected to have the systematic capability to analyze, dissect information and identify solutions to problems even outside their area of specialties’. The number of engineers (per capita or per university degrees) in Finland is roughly double as much as in many other OECD countries, only South-Korea has higher density of engineers. [6]

Changes of the working life has influence to the requirements of education [1]

Concurrent Engineering (CE) and Collaborative Planning (CP) [2] were both introduced as operational models and as a best practice when they appeared in 1990’s to improve the competitiveness of companies in these respects. The goal of these approaches is the same although CE focused on internal collaboration with adapting the customer into the processes. The goal of CP was to collaborative planning of the logistic chains to the profits of all parties.

Similar approaches should be deployed in educational processes, as well as take into account a holistic and comprehensive planning and delivery operation from supplier (i.e. teacher) to customer (i.e. students). In an opposite case the personnel will lose sight of customer (student). Thus they are able to develop their own operation but will do it at the expense of the integrity.

Working in a real working environment means a continuous development process and therefore the change management is an important part of teaching. The ability of effective acquisition of information is an essential part of this. Students must learn to flow in the refining process upwards and downwards during his/her student years by migrating his/her qualifications and skills.

The Finnish industry has moved towards the customer and amended their products significantly. The companies try to dominate their own role in supply chains, the customer relationship has been tightened and the customer service has become consulting service taking over the traditional customer oriented duties, such as product design and manufacture.

The products are renewed frequently and more often based on the initiative of a customer. The amount of product variations has increased in pursuance of non-standard individualized and customized products.

This development cannot be ignored and bypassed while the competence requirements are set. In these situations, change management and understanding the comprehensive operations should be highlighted.

The changes in the economic life and generally in the society have been radical and sweeping: the work is globally distributed, not to forget the new emerging nations. The industry is worried about the availability of work force and it is anticipated that only half of the industry will be able to recruit sufficiently qualified staff in the coming years. The focus and challenging interests of the industry in Finland have changed substantially from 1993 to 2003. In 1993 the customer service and quality were ranked to be the most important objectives while in 2003 the production costs were raised to be the most important objective in development (Figure 1 and Figure 2).

Figure 1. Changes of Targets of Industry in Finland 1993 – 2003. [3]

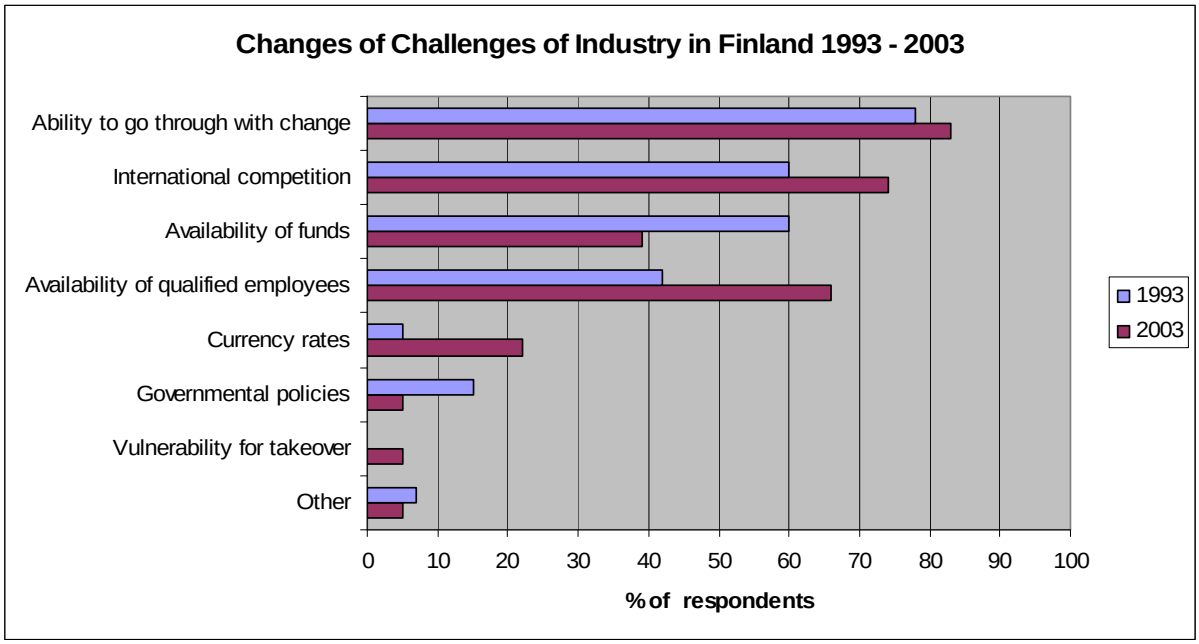

Figure 2. Changes of Challenges of Industry in Finland 1993 – 2003. [3]

Changes of the working life due to outsourcing and changes of business models enforce the engineering education to be changed respectively (Figure 3). There is a need to educate people who are able to transfer easily from a position to another and from a profession to another during their lifetime. The changes of surrounding society and business life must be reflected and have an effect on engineering education.

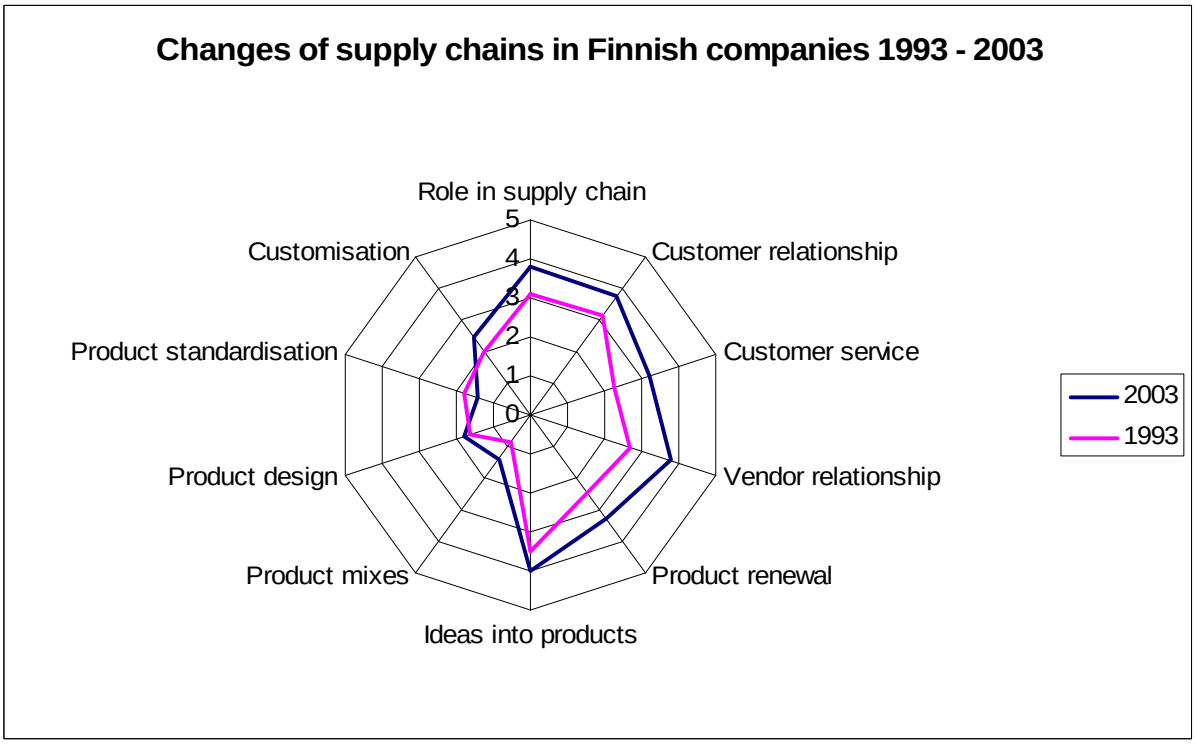

Figure 3. Changes of supply chains in Finnish companies 1993 – 2003. [3]

SELF-EVALUATION

The aim of the self-evaluation is to find out development areas to focus the efforts and resource allocation in future. It is seen that this evaluation is a part of the overall continuous development process of the university of applied sciences. Thus our development work has a relationship to the national evaluation of higher education institutions (HEIs) which will be carried out in three years time – the self-evaluation is executed and will be documented so that there will be measurable evidence of the improvements when the new self-evaluation with the site visits of the national evaluation board will take place. In this way the development work done in practical level meets the needs of the top management [4]

CDIO framework and its 12 standards [5] are to be used to give a consistent structure for the evaluation. The evaluators were given a summary of CDIO standards translated into national language, i.e. into Finnish. Each evaluation was carried out in 20 different degree programmes having a curriculum of their own.

The implementation process is organized by creating an advisory board that consists of the directors of the engineering schools, some pedagogical experts, the communication manager and a few students. A working group of four authors of this paper is coordinating the real implementation work, and all the interested staff is called to join the everyday work.

One significant challenge is to find a balance between the issues students have to learn during the time of the studies – which ones they need only to know how to retrieve the necessary information later on – or even just to know how to find someone to help – which things can be left to be learned when they are faced in working life, and which ones are so fundamental that you cannot even understand the task without mastering them.

The self-evaluation of the CDIO implementation at Helsinki Metropolia UAS was carried out during the spring semester 2009.

The five evaluation questions of the self-evaluation were as follows

1. How important the standard is seen in your degree programme (range 0 – 4)
2. What is the current situation in your degree programme regarding the respective standard? (range 0 – 4)
3. The current situation and its strengths
4. The current problems
5. The target situation and actions to be done within three years time

The Table 1 contains the preliminary results of the self-evaluation.

Table 1. Self-evaluation of the CDIO implementation at Helsinki Metropolia UAS

Standard	Importance	Current situation	Current situation and its strengths	Current problems	Target situation and actions and resources to be taken within three years time
1 — CDIO as Context	4	3	various projects and work-based learning activities; active teaching/learning, pedagogical studies, small teaching groups	further integration of core and professional subjects; team teaching; timing problems; collective labor agreement	better schedule management; team teaching deployment;
2 — CDIO Syllabus Outcomes	2	2	competence-based curriculum under construction; detailed outcomes missing; identification of soft skills missing; inconsistence	not too much willingness to reformulate the curriculum in details	competence-based curriculum by 2012
3 — Integrated Curriculum	3	1	missing integration of mutually supporting disciplinary subjects; existing projects (2 – 4 for each student) integrate to some extend	delivery of mutually supporting disciplinary subjects	module based curriculum and team teaching with a superior teacher of one period (i.e. 10 weeks) for each class
4 — Introduction to Engineering	3	1	implementation of a project on Introduction to Engineering has started 2008	how to integrate the subjects of Introduction to Engineering: not too difficult, not too easy; heterogeneous starting groups	proficiency in Introduction to Engineering among the faculty should be acquired
5 — Design-Build Experiences	4	4	Design-Build Experiences has been implemented many years ago in a form of projects with professional suitability, some of them are work-based and some on commission	learning aspect may have been undervalued compared to the quality of outcomes	better implementation of bigger projects with challenging results; R&D activities incorporated with potential financial incomes
6 — CDIO Workspaces	4	1	current situation is inadequate;	some projects do not require workspace and laboratories (like business and economics); ICT has a moderate requirements but most engineering disciplines require a significant space	new buildings with appropriate functionality are needed
7 — Integrated Learning Experiences	3	1	teaching and subjects are too much independent from each other and integration is left on the shoulders of students	holistic learning is not understood by the teachers	more qualified pedagogical methods should be implemented
8 — Active Learning	3	2	methods of active learning are deployed to some extend	too much lecture-based teaching	activating web-based teaching approached should be developed
9 — Enhancement of Faculty CDIO Skills	3	1	no actions have been taken so far; faculty has been enthusiastic about CDIO approach; a need for change has been admitted	ignorance of CDIO skills; ignorance of the real consequences of CDIO; shortage of human and financing resources	gradual progression
10 — Enhancement of Faculty Teaching Skills	3	1	generally teaching skill are good; faculty has been enthusiastic about CDIO approach; a need for change has been admitted	ignorance of the real consequences of CDIO; shortage of human and financing resources; pedagogy is not so much appreciated among faculty	gradual progression; pedagogical strategy should be developed
11 — CDIO Skills Assessment	3	1	so far is based on "common sense"	no systematic practices to carry out assessment of student learning in personal, interpersonal, and product and system building skills, as well as in disciplinary knowledge	a systematic practice must be created and adapted
12 — CDIO Program Evaluation	2	1	study programme evaluation has been carried out with other criteria	involvement of all stakeholders	system should be created; system should be approved by the national accreditation agency

As one can see in the self-evaluation (Table 1), the biggest challenges at Helsinki Metropolia UAS are related to concrete problems which concern workspace and laboratories. They become extremely important prerequisites when introductory and capstone project are carried out. Some of the study programmes are more flexible regarding the physical working environment, like business and production economics. The requirements of ICT related projects are moderate compared to the real massive requirements of construction, machine, mechanical, and process engineering.

Another great challenge concerns the type of project assignments. Are they based on working life assignments or educational assignments? How realistic the assignments should be? A real customer may require real outcomes in a realistic environment. A real customer may be interested in requiring results of good quality and they may be willing to award some kind of scholarship or financial support.

CONCLUSIONS

To avoid change resistance and get success-stories, pre-work should be well executed. This task is usually underestimated, and thus much unnecessary problems are faced during the implementation. Implementing CDIO should follow the guidelines of CDIO! In the light of all above considerations, this presentation should encourage the collaborators who are considering to start the implementation.

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Biographical Information

Markku Karhu is a Director of degree programmes in Information Technology, School of Information and Communications Technology at the Helsinki Metropolia University of Applied Sciences, Espoo, Finland, and a local collaborator of the CDIO Initiative. His current interests are in pedagogical development activities of the engineering education, not only concerning regular degree education for youngsters but also continuous engineering education for adults.

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