BENCHMARKING TEACHING AND LEARNING PRACTICES IN FINNISH ENGINEERING EDUCATION

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ABSTRACT

As part of a national engineering education development project, the Finnish universities of applied sciences were asked to report their best practices in engineering education. Special focus in the questionnaire was set on successful case studies dealing with teaching and learning methods, innovative industrial co-operation, student counseling, and curriculum development. Finally, almost 70 case descriptions representing a wide selection of well-proven educational practices were reported. In this paper, the benchmarking process is described and the results are analyzed. Moreover, it is studied how these results relate to the educational vision drawn by the CDIO standards.

KEYWORDS

Teaching and learning methods, project based learning, PBL, facilitating change, co-operation

INTRODUCTION

The Finnish universities of applied sciences (UAS) started a national engineering education development project in spring 2008. The main goals of this three-year project are to increase interest in engineering studies among the applicants, to decrease the number of dropouts, and to speed up the graduation of engineering students.

The project implementation is based on three working groups focusing on the following core areas: Marketing communication, Structural development, and Teaching and learning processes. The main task of the Marketing communication core group is to support the advertisement campaigns directed mainly to senior high school and vocational school students. The assignment of the Structural development core group is to study the long-term trends and needs for Finnish engineering education, and to produce a suggestion for the future degree program structures and admission processes. The Teaching and learning process core group started its work in autumn 2008. The assignment of the group is to strive towards the project's goals by facilitating co-operation between the universities and their staff working with engineering education. In addition, the group was asked to identify, analyze and share good engineering education practices in order to encourage their efficient utilization in other Finnish engineering UASs, too. This paper presents the work of the Teaching and learning process core group.

BENCHMARKING BEST PRACTICES

What kind of actions could be taken so that they would lead towards the defined project goals? There have been many different development projects during the recent years focusing on versatile aspects of higher education. In addition, the universities have been working with the same problems for a long time. On the other hand, there still are true challenges in engineering education, and there could be much more co-operation between engineering educators – within the universities, nationally and internationally. In continuous development often small improvement steps play an important role in the process. There are too many good practices, methods and important experiences that have never been shared.

Benchmarking is a method to develop activities by learning best practices from other organizations. It has been defined as a continuous, systematic process for comparing the performance of, for example, organizations, functions, processes or economies, policies or sectors of business against the "best in the world", aiming not only to match those performance levels, but to exceed them [1] [2].

Benchmarking is strongly related to quality aspects and development of quality management in organizations. It goes beyond the traditional competitive analysis to not only reveal what the best practices are but also to obtain a clear understanding of how best practices are used. The method is widely used in industrial quality programs, but also in the public sector. Especially the field of education is a good target of application because most of the processes, functions and practices are generally used in every educational institute. Therefore, they are easily compared, learned and applied.

Benchmarking is first and primarily, a learning process structured so as to enable those engaging in the process to compare their services, activities, and results in order to identify their comparative strengths and weaknesses as a basis for self-improvement and/or self-regulation. Benchmarking offers a way of identifying "better and smarter" ways of doing things and understanding why they are better and smarter. These insights can then be used to implement changes that will improve practice or performance [3]. A best practice cannot be imposed; it has to be adapted to one's own organization style [4]. This means that one cannot just pick up a "best practice" and surgically implant it on one's own organization. One has to look at the way things are being done, the culture prevailing and the human resources employed to do the job before one can adapt a process.

A fundamental benchmarking process contains five major components; plan the study, search for benchmarking partners, observe the partners' process, analyze the gaps in performance and the causes for them, and adapt the best practices [5] [6]. In principal, benchmarking is two things: setting goals by using objective, external standards and learning from others – learning how much and, even more important, learning how. It means that benchmarking is not a numbers-only exercise, but also practices exercise. Practices are defined as the methods that are used; metrics are the quantified effects of installing the practices [1].

Benchmarking can be divided to several categories according to the target of learning and target of development (internal, competitor, functional, generic) [1] [2] [7]. In addition, Boxwell [4] mentions two common categories of benchmarking; co-operative and collaborative. The last two categories are interesting because they are relatively easy to practice and they consider several organizations at the same time instead of traditional bilateral benchmarking. Jackson et al. [3] [8] have developed a benchmarking method especially for higher education. In addition, they have made a further division to these categories. The most useful categories are described by Kleemola [9] including the method used in this project. The main idea is to comprise a network of organizations which can utilize the best practices continuously choosing the right organization from the network for each development target.

A NATIONAL SURVEY IMPLEMENTATION

It was decided to implement a benchmarking survey on successful teaching and learning practices of engineering education in the Finnish UASs as part of the project. The goal of the study was to identify good engineering education practices, and to share them at a common knowledge base in order to encourage and facilitate new development activities. Successful case studies were searched especially dealing with teaching and learning methods, innovative industrial co-operation in education, student counseling, and curriculum development. However, the UASs were encouraged to report any practices connected to engineering education that they have considered worth sharing. Each case was asked to be reported using a common template including, for instance, a SWOT analysis and a discussion on the future development perspectives of the case.

The survey was started in January 2009 by sending an invitation to all Finnish UASs with engineering degree programs. The invitation contained detailed participation instructions and a template to be utilized when reporting the case studies. There was no filtering review process included since it was seen important to welcome all case studies considered worth publishing by the UASs themselves. Instead, the members of the Teaching and learning core group supported the authors in the different phases of the process to refine their contributions.

After the submission deadline the Teaching and learning core group members studied the received descriptions. Brief summaries analyzing the main results and critical success factors of each case were written by and published in [10]. The intermediate results were presented in an engineering educator's seminar organized by the project in November 2009. The survey was re-opened for additional submissions until mid-January 2010, and the authors of the already submitted case studies were given an opportunity to revise their work within the same schedule.

Before the first deadline in spring 2009, 54 case studies were submitted to the survey. Finally, 17 additional papers were received before the final deadline but two originally submitted papers were left out by the authors. Accordingly, 69 descriptions of good engineering education practices were published in March 2010 [11]. The summit of the survey was a national

Engineering Education Forum 2010 that gathered 350 engineering educators to share their experiences on different topics in teaching and learning in Hämeenlinna March 17th-18th 2010. Approximately 50 of the reported best practices were presented by the authors at the seminar, and the overall feed-back from the participants was very positive.

RESULT OVERVIEW

The reported case studies provide a versatile review of the challenges of Finnish engineering education in general, and the attempts to solve these challenges in particular. Furthermore, all the cases have been considered successful and worth presenting and sharing by their authors. That is, the study presents an interesting view to current ways of implementing and developing engineering education in Finland.

Most cases revealed that we are moving towards a more collaborative way of teaching and learning. A rough classification of the cases is listed in Table 1. Most authors classified their case in the category "teaching methods". Of these quite a few dealt with industrial cooperation in one form or another, and the applied teaching method was in many of these cases project based learning. Several cases dealt with student counseling and a few with curriculum development. There were fewer descriptions of good practices integrated into traditional teaching methods. The class "other" includes descriptions of student internship in Finland and abroad, arranging student seminars, fairs and other events that support learning and professional development.

Table 1
Classification of the received cases.
Some of the submitted 69 cases could be classified in more than one of these categories.

	Teaching methods	Industrial cooperation	Student counseling	Curriculum development	Other
Number of cases	51	29	13	11	23

Industrial Cooperation in Education

Many of the case studies described learning processes that include industrial cooperation and involve commissions in which students, working in pairs or small groups, explore versatile real-world projects for an enterprise or in cooperation with enterprise employees.

The best benefits have been achieved when both parties, the enterprise and the university, have been able to co-operate for several years and to build a win-win relationship. During recession good and lasting relationships have been valued by both parties. The alumni and eager members of the teaching staff have been a valuable asset in the cooperation. In many of the described cases there have been difficulties in finding the mutual time necessary. Combining the schedules of university life and working life has brought its own challenges to the co-operation.

Teachers frequently reported that working with projects dealing with real-life assignments and problems have given the students possibilities to develop cross-curriculum skills as well as generic skills. This has given the students confidence and assurance that they are working towards a goal of proficiency and a career as skilful engineers. The students feel that their work is of significance also for the enterprise they are working for. This mode of teaching has

influenced student motivation in a positive way and thus also the passing rate. In many studies in higher education it has turned out that the time that students spend on their studies is not nearly what is assumed and allocated. Applying project based learning, where students have a possibility to work on real-life problems, has substantially increased the time students spend with their studies. [12] [13]

The cooperation with the industry has taken many forms. The university has arranged seminars for the employees and students, briefing sessions on student assessment and evaluation, and seminars based on student experiences of their internship. These forms of functions have brought about an active dialog and a well-structured cooperation. A well established cooperation between the UASs and the industry has in many cases, shown a substantial influence on regional development as well.

Problem Based Learning

The survey included several cases in which problem based learning (PBL) was applied both as a curriculum development and instructional system. In PBL the students try to find solutions to problems which reflect versatile problems from real life. Using PBL has given a sophisticated way of decreasing the gap between theory and practice. It is also a natural means by which knowledge from several disciplines can be integrated.

It has been necessary to devote much time and effort when the organizations have started off to use PBL. In some of the cases staff members and in other cases students have shown prejudice towards this teaching method, but eventually PBL has turned out to be successful. This method seems to need lots of guidance for all parties. Getting results demands that both lecturers and students know their roles and act accordingly.

In both project based and problem based learning applying theoretical knowledge to practice is emphasized. Project based or problem based learning do not appeal to all students. Many different reasons can account for this. The students' former study habits may be such that they are used to the teacher holding all necessary knowledge and all that the students have to do is to be the target of transfer. Students' self-directed learning readiness and self-efficacy might be such that they feel that other teaching methods suite them better. Learning styles also influence student learning and student opinions of the teaching arrangements. Some students wish for more advice and guidance than it is possible to arrange. Students' dependence on getting guidance from lecturers or other authorities is very individualistic and is not necessarily related to their knowledge or skills. Dependence might show up when they are confronted with new situations or problems. They might find it difficult to see that they have sufficient knowledge and experiences to deal with the given problems or commissions. To educate students who are able search for and process information and to solve problems on their own or as a team is an important learning goal. In most learning modes, based on collaborative working methods, there are always those who are equipped with a well developed free-rider mentality. These students cause sorrow and annoyance both for lecturers and fellow students.

Assessment

The assessment criteria and transparency of assessment have an important role in how students set their learning goals and work towards them. Assessment and feedback thus have a substantial influence on student learning. It is important that students get constructive feedback on their work in the beginning of their studies so that their self-efficacy and learning readiness skills are improved. The learning environment should also have a configuration where students'

self-assessment skills and peer assessment skills are promoted. Students should be able to improve their critical thinking and self-assessment alongside with their increasing knowledge base. These skills are invaluable when moving on to the working life. In some of the cases views on assessment were mentioned and there were several comments that expressed that it was specially challenging to assess project based learning and problem based learning. This is understandable if traditional teaching methods have been more commonly used before changing to a more constructivist approach to teaching and learning.

Other themes and findings

There are several examples on how to integrate internship included in the degree program with both teaching and the research and development programs of the university. Integrating the research and development activities in the education has turned out to be challenging. The challenge is in finding such R&D projects in which the students are able to gradually take more and more responsibility. Success in this field is not unique but has, without exception, been a result of an innovative approach and good planning. Most research projects are one-time projects and include only the teaching staff. There are however, some very successful exceptions to this where students have been able to work alongside with the university staff and industrial employees.

The cases also include examples on how mathematics and natural sciences can be integrated with other subjects and thus become useful tools for the future engineers. It was most satisfying to see that collegial and constructive cooperation amongst the lecturers has led to a much broader view on the importance of diverse subjects to an engineer.

DISCUSSION

In this paper, a survey on good teaching and learning practices in the engineering education of Finnish universities of applied sciences was described. The goal of the survey and the publication of the reported practices was to facilitate sharing ideas and experiences amongst the engineering educators. We hope that this effort is a step towards an open and active benchmarking process that benefits all the participants.

Some of the described practices have had extra funding during the developing stage but after this they have been able to function on normal resources available. Some have been executed without any extra funding, merely depending on an eager and skillful staff. Unfortunately, some of the cases are not able to outlive a drop in the funding which is inevitable in the long run. These have to find some creative ways to be able to continue even after their piloting stage. We are confident that they will succeed.

When comparing the reported practices with the CDIO standards [14], it can be noticed that in most cases engineering education has been developed in the spirit of CDIO and that the CDIO standards are met to a large extent. For example, the reformation of Physics laboratory courses has been carried out by putting special effort on holistic conceptualization, problems from the industrial life, deeper understanding of relevant concepts, integration of several disciplines and practicing experimental working and written and oral presentation. The labs are done in groups with joint responsibility and taking turns in leadership. The reformation work has been carried out as a team work headed by the physicists working together with lecturers from other departments and representatives from the industry and the alumni. The structure of the courses has a spiral nature and further developing will continue on basis of feedback from all parties concerned.

Many of the other cases represent working modes which fulfill the CDIO standards, too. Working in groups, active doing, using blended learning, putting effort on student counseling and a transition in the teaching and learning culture to a more collaborative direction well meet most CDIO standards.

This project applied the collaborative one-to-one partnership benchmarking model in which several organizations in the network choose one best practice and one organization at a time to be a learning target [8] [9]. It was possible because all the best practices are described in the publication [11], and because the names of the writers are known and they can be contacted later. This time the focus was on practices not on measures. The improvement in performances achieved with the described best practices is not always measurable. However, it is not necessary, because all the practices have been used and found successful during several years. The applied collaborative one-to-one partnership benchmarking is simply a method for an organization to learn from several organizations.

However, it is important to understand that there is no success in learning best practices if they are not properly applied into one's own organization. The best practices are described in the publication [11], but they need to be comprehended, perhaps by contacting the authors, adopted and adapted before they are beneficial. Therefore, this project is not yet at an end. It offered a possibility to learn, but the job has to be done by the educators themselves.

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