Enhancing engineering education through student engagement: the introduction of partner company R&D project work into the syllabus

**M. Kristiina Meltovaara, Juha Leimu**

Technology, Environment and Business, Turku University of Applied Science, Turku, Finland, kristiina.meltovaara@turkuamk.fi

Technology, Environment and Business, Turku University of Applied Science, Turku, Finland, Juha.leimu@turkuamk.fi

Abstract

Students increasingly commence university degrees with little or no relevant engineering work experience thus lacking the basic understanding as well as the basic practical skills of how a working environment functions. The need for a change in the engineering education has been recognized worldwide ([www.CDIO.org](http://www.CDIO.org) and engineerofthefuture.illinois.edu). The Turku University of Applied Science (TUAS) has taken part in both the CDIO framework and the Engineering of the Future summit and has implemented changes to its syllabus in order to address these current important questions.

TUAS has also adapted the innovation process already widely adapted by successful companies to the higher education system to provide students with appropriate knowledge and tools to further promote innovation processes and innovation management. Kettunen 2009 emphasizes that the adoption of the innovation process should become an ‘innovation pedagogy mindset’ of the higher education system in addition to the legally defined goals of the higher education system1. Kettunen emphasizes the innovation pedagogy cornerstones to consist of interdisciplinary operations, R&D, curricula and internationalization as well as entrepreneurship and service activities.

Long term co-operation between TUAS and a leading machine manufacturer was begun in 2002. The manufacturer had within their r&d department had plans to test a new concept, this however had bound their key experimental in house key resources for a substantial time. The new concepts strategic importance was also re-evaluated and in-house resources were redirected to other projects. TUAS and the manufacturer however formed a two year project agreement, where the work was organized into a chain of student projects: knowhow and learning cumulating from group to group with particular attention paid to overlapping scheduling where gained experience and silent knowledge was passed over from one group to the other. Practical experience as to the importance of co-operation and communication within and between the groups was obtained by participating students within a controlled teacher supervised environment. Continuous and open contact between the manufacturer and teaching staff is of essence to successful completion of the project work, all aspects relevant to manufacturers R&D requirements are in this way also thoroughly addressed. Students obtain hands on experience of working with trade tools applicable to a wide area of machine manufacture and automation.

In conclusion, the innovation process, in which a manufacturer’s product development skills and a higher education establishments service center, providing teacher know-how and student learning possibilities, has numerous advantages for students, the teaching staff and businesses. Students are provided with hands on experience and companies with future employees well aware of the importance of project work and information sharing. Higher education business partners are also provided with a means to enlarge in-house competences and also simultaneously access to an innovation process leading to innovative profitable products with a competitive edge.

1. Introduction

Students increasingly commence university degrees with little or no relevant engineering work experience thus lacking the basic understanding as well as the basic practical skills of how a working environment functions. The engineering programmes have been planned years ago, when all or most students commencing their studies had at least one year of practical working experience. This meant that students were familiar with the practical work and also had basic understanding as to how an enterprise functions with its own internal culture and rules. The theoretical teaching given in the classroom environment was based on this prior work experience and therefore practical laboratory tests were deemed as an adequate supplement to the theoretical teaching.

As the student now possess little or no relevant work experience or either commence university directly from high school, a lack of practical skills and a lack of the basic understanding of working environment can be observed within the student intake groups. This has had a direct impact on the teaching requirements.

The need for a change in the engineering education has been recognized worldwide ([www.CDIO.org](http://www.CDIO.org) and engineerofthefuture.illinois.edu). CDIO notes that upon graduating engineering students should be able to Conceive, Design, Implement and operate complex value-added engineering systems in a team based engineering environment. The Engineering of the Future summit centers around student involvement in engineering education, as well as the concept of how to enhance the role of student engagement to be an increasingly powerful force in transforming engineering education. The Turku University of Applied Science (TUAS) has taken part in both the CDIO framework and the Engineering of the Future summit and has implemented changes to its syllabus in order to address these current important questions highlighted by both the aforementioned.

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2. Implementing syllabus changes

TUAS has adapted the innovation process already widely adapted by successful companies to the higher education system to provide students with appropriate knowledge and tools to further promote innovation processes and innovation management. Kettunen 2009 emphasizes that the adoption of the innovation process should become an ‘innovation pedagogy mindset’ of the higher education system in addition to the legally defined goals of the higher education system1. Kettunen emphasizes the innovation pedagogy cornerstones to consist of interdisciplinary operations, R&D, curricula and internationalization as well as entrepreneurship and service activities. In other words, innovation pedagogy aims at providing students with professional multidisciplinary skills that enable them to participate in the innovation process of their future organizations.

The studies previously contained only basic courses during the first two years of study e.g. mathematics and physics. After the syllabus change the first year contained 60% of basic courses and 40% of professional studies e.g. mechanical engineering. The second year contained equal amounts of professional studies and basic studies. During the third and fourth year the basic studies continue and the strong connection to the professional elements improves the study motivation as well as the student skills to apply their theoretical skills to solving practice related problems. Thus students gain during their first two years at the TUAS a sufficient professional knowledge basis allowing them to participate in project type of studies and also part take in project work. Prior to this change project work was only carried out during the last two years of studies.

A good example of changes in the syllabus are statistical method studies. Before the change, the quantitative research methods were studied separate with a loose or totally lacking a connection to the working life of an engineer. The same way teaching was concentrating on solving lottery probabilities. These were now combined to statistical process studies aimed to give applicable competences for planning experiments and analyzing measured information. Both of these are highly appreciated skills in the field of technical development. These studies also give the students the prerequisites to carry out measurements related to R&D work. These measurements, furthermore, enhance the understanding of the relationships between processes, measurement and phenomena.

**2.1 Project work set up**

Long term co-operation between TUAS and a leading machine manufacturer commenced during 2002. The manufacturer had year ago patented a new type of roll, which had good electricity consumption reducing potential. The energy consumption of such a system has widely been researched (Juppi, 2001) (Leimu2008). The manufacturer had initially planned to test the new equipment with its own simulators and pilot it at its own research facility. The testing process however turned out to be slow and expensive. Furthermore, the new concepts strategic importance was re-evaluated and in-house resources were redirected to other projects. TUAS and the manufacturer however formed an alliance: a two year project agreement was set up. The approach was to build a small-scale model of the new type of roll and the drying fabric with which it made contact. At TUAS the work was organized into a chain of student projects: knowhow and learning cumulating from group to group with particular attention paid to overlapping scheduling where gained experience and silent knowledge was passed over from one group to the other.

The project work was planned in the degree program of industrial management engineering, it was however obvious from the beginning that the best results were achieved by organizing the groups from different engineering degree programs. Most degree programs include project studies. The basic project is 5 ECT credits, which means 135 working hours for each student. This dimensioning is good from the progress of the research and fit well into the syllabus. In several cases the project size has been fitted to need. Most of the participating students are second and third year engineering students. During this process there have continuously been one or two spontaneously formed student groups waiting to participate in the project work.

The partner company subsidized TUAS by providing their engineering expertise in the set up stages of the experiment, by providing the cylinder to be measured, the measurement machinery as well as the major part of the measurement equipment by which the information is stored. They set up the equipment to be tested, instructed the first student groups as to how the equipment worked and also helped with the first problems encountered.

Continuous and open contact between the manufacturer and teaching staff was of essence to the initial implementation but also the successful completion of the project work, all aspects relevant to the manufacturers R&D requirements were in this way also thoroughly addressed. The teaching staff of TUAS also participated in the project by forming part of the project steering group. Meetings of the steering group were held regularly, and also on demand. The work that had been undertaken was discussed as were any problems and questions arising from the work. The next steps of the work to be undertaken were discussed and agreed upon during the meetings. A cross-professional team was easily able to recognize and pick out a number of problems to be solved by the student teams with varying engineering backgrounds.

One of the main factors in obtaining the two year contract with the manufacturer was the understanding the TUAS staff had of the partner company’s research and manufacturing process as well as the understanding of both the internal and external business environment in which the manufacturer operated.

**2.1 Work undertaken**

The extensive use of student labour was the basic idea in the process from the beginning. Student work was organized into a chain of student projects. Practical experience as to the importance of co-operation and communication within and between the groups was obtained by participating students within a controlled teacher supervised environment. All the methods and equipment used during the project work are common tools in the development work of the machine industry; in other words, all the skills learned by students during the project can be applied an put in to practice in different areas of machine building and automation.

In the first instance, the students made a suggestion for a test rig which acted as the basis for the experiments to be carried out. An engineering competition was organized for this. Three student groups presented proposals in the form of tree-dimensional computer models. The manufacturer then manufactured the test rig on based on the winning three-dimensional model.

After the delivery of the test rig, two new groups started their work. One planned the experimental work layout, moved the equipment to its final location and also performed the start-up of the rig. The other group began planning the data logging system. These groups were followed by measurement groups and further data logging system development groups. Continuous system development was undertaken based on the feedback from the measurement groups.

At the start each group received their instructions from the tutor teachers. In spite of careful guidance mistakes happened. During the first half-year period, the most common results were smoke and damaged equipment. Consequently a change of organizing the work was undertaken; each new measurement group now worked two weeks side by side with the previous one, participating in the routines. These overlapping working periods, which allowed for information sharing between the participating students, practically ended equipment damages and also had a clear positive effect on the measured data quality.

The following table highlights the number of students involved in each phase of the study as well as the credits student obtained. A total of 52 students participated in this R&D project and they obtained a total of 216 credits for the work undertaken.

Table 1: Measurement groups and credits obtained for work undertaken.

|  |  |  |  |
| --- | --- | --- | --- |
| Task | students | credits/student | credits/total |
| Engineering competition | 15 | 5 | 75 |
| Start up | 2 | 5 | 10 |
| Data logging system development 1.0 | 5 | 5 | 25 |
| Measurement group 1 | 5 | 5 | 25 |
| Data logging system 1.1 | 5 | 8 | 16 |
| Measurement group 2 | 5 | 5 | 25 |
| Verification measurements | 5 | 3 | 15 |
| Data logging system 1.2 | 5 | 5 | 25 |
| Measurement group 3 | 5 | 5 | 25 |
| Article writing project | 8 | 5 | 40 |
| Measurement group 4 | 5 | 5 | 25 |
| Layout change and restart | 5 | 5 | 25 |
| Non linear regression group | 4 | 5 | 20 |
| Measurement group 5 | 5 | 5 | 25 |

3.0 Developing the concept further

The major benefit of this type of work is that simultaneously operating student groups with differing objectives have to communicate effectively with each other. This familiarises students with the importance multidisciplinary working teams, a skill previously learned once entering working life. The importance of communication between simultaneously working groups and subsequent groups is also highlighted. Furthermore, each student is required to report the work undertaken orally and also in writing. The inclusion of an increased number of written work in the syllabus has resulted in positive feedback from the business environment in which the students graduating after studying under the new syllabus are working in. Positive remarks have been made about the quality of the written work produced by graduate recruits.

The inclusion of a company has made the project work more “real” to the students. The importance of deadlines is understood and work organised accordingly. The quality of the presentations to the companies has been observed to be of greater standard than traditional presentations given to only the student group.

R&D project work has in this case provided an excellent teaching method by which the importance of team work and information sharing between teams and team members has been highlighted. However, a number of issues arose, which have to be addressed during future project work. One of the issues the tutors faced was that this method was an excellent teaching environment for a third of the students, students who also excelled in their other studies. For one third of the students additional tutor work in the form of additional guidance and support was required. For one third of the students it was found that the work was left to the tutors. One of the issues arising from this project type of R&D work is, how to involve all the students, in particular the passive ones who have to be given alternative work. This in turn results in additional costs to the teaching department and also does not provide students with the required skills and knowhow. Another issue is the teaching staff skills required to tutor these type of projects. Tutors are required to keep continuous contact with the partner company as well as student groups. The project type of teaching method is also more taxing than traditional teaching.

Upon the successful completion of the project, the results obtained quickly spread within the local business environment. Numerous projects have been offered to TUAS to be carried out by student groups. One of the issues faced in accepting any of these projects is the space requirement of the R&D work to be undertaken. The class rooms and teaching facilities have been constructed to meet the needs of traditional theoretical class room teaching, not for multidisciplinary project work.

4. Conclusion

 In conclusion, the innovation process, in which a manufacturer’s product development skills and a higher education establishments service center, providing teacher know-how and student learning possibilities, has numerous advantages for students, the teaching staff and businesses. Students are provided with hands on experience and companies with future employees well aware of the importance of project work and information sharing. Higher education business partners are also provided with a means to enlarge in-house competences and also simultaneously access to an innovation process leading to innovative profitable products with a competitive edge.

The successful completion of a project of this type requires long term commitment from both parties: the company and the higher education organization. It furthermore requires continuous communication of both parties involved. In addition the company has to be willing to transfer their process knowledge to the higher education partner, who on the other hand has to be willing to absorb all the information provided and act accordingly. Utilizing the mixture of student skill and teaching staff expertise can significantly aid a company’s R&D activities. The benefits to the higher education system are that students obtain authentic experience of multidisciplinary project work. Students are also able to practice their communication skill, not only within their own team, but also with other teams, whilst passing on relevant information, silent know how and expertise. The importance of information sharing is highlighted as hands-on experience is gained on effective communication and co-operation skills within a controlled environment. The needs and requirements of working life also become clear to participating students.

A number of issues such as involving passive students in project work or providing them with other work, the lack of adequate project work facilities and the increased demands on teaching staff project work are issues which need to be addressed in future projects. In conclusion the inclusion of R&D project work in the syllabus has greatly enhanced student involvement and has resulted in graduates with project work, communication and co-operation skills as well as a basic understanding of the way the working environment functions.

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