The challenges of integrating R&D activities into educational processes

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A modern educational organization has to face many kinds of challenges these days. Even institutes focusing to degree-oriented education have to be more and more, not only aware of the needs of the industry, but also co-operating with them in several fields. Companies expect schools to 'produce' engineers which have 'customized' skills and already have practical experience. On the other hand schools are also expected to have expertise to solve practical problems and to help companies to develop new products.

In HAMK University of Applied Sciences a very important toolbox for facing these challenges is offered by research centres. The mission of these centres is to act as a regional developer by offering training products and applied research services for companies. Research centres have also an important role in the area of degree oriented training. With research centres a university can educate students to become future experts by having good practical skills and by being familiar with latest technology. At the moment HAMK has 9 research centres, each of them working in different substance fields. This paper will focus on connections between R&D activities and education in two of them, AutoMaint and InnoSteel.

AutoMaint is research centre focusing to production efficiency, automation and maintenance. For practicing its educational mission, AutoMaint recruits each year students for their 6 months practice period. During the practice period students are acquainted deeply in some substance area. In AutoMaint this consist of control systems of automation, robotics, automated data collection and data analyzing of production, distance control systems, maintenance information systems and so on. Students are guided by senior students and employees. In the end of their practice period students design and accomplish a larger automation application. These projects are mainly used to develop AutoMaint's learning environment by enlarging it with laboratory installations and e-learning environments. During the next term, students work as assistants in basic courses and they also guide new students in laboratory practices. In their second summer the students go back to full-time working and they can take part in company projects. At this stage they are also ready to guide new trainees. There are great benefits in using advanced students as instructors; advanced students can recall easily the difficulties of beginners and on the other hand the beginners do not hesitate to ask guidance from their co-students. From learning perspective it is also good that the advanced students must repeat basic facts and understand the whole context better and better when they advice novices. Learning by teaching is also one way to earn the respect of novices and improve the growth of professional identity.

The other example – InnoSteel – is based on a different approach. HAMK in co-operation with industry and with public funding has developed a new way to improve the know-how in the area of local metal industry. From HAMK's perspective InnoSteel consists of a group of applied research projects, which are mainly focused on local small and medium sized enterprises on metal branch. In addition to the projects InnoSteel contains a training factory managed by a non-profit company owned by HAMK, local cities, schools and a group of local companies. In general InnoSteel is a central node of a large network, thus providing a wide interface for industry focused challenges and projects for teachers and students of HAMK.

By combining applied research activities executed in various research centres to educational processes HAMK has a wide potential to offer practical experience and real life challenges to the students during their studies thus preparing them better to meet the expectations of their future employers.

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RESEARCH UNIT AUTOMAINT AS A PART OF THE UNIVERSITY OF APPLIED SCIENCES

HAMK University of Applied Sciences is one of the biggest of its kind in Finland. There are several units in seven different locations. In Valkeakoski unit there are three degree programs and one research unit. The degree programs in Valkeakoski unit are Automation Engineering, Industrial Management and Engineering and International Business.

The main focuses in the research unit are automation and asset management. The R&D activities in the unit are mainly focused on applied research. The task of the research unit is to act as a driving force in the region through research and education. Education is offered both to the local industry and to the degree programs of the unit. The detailed fields of education and research are for example automation systems, automation control systems, automation of material handling, multimedia, information systems, industrial simulation etc. The research unit offers many different courses for the degree programs. The research center continuously employs 20-35 people. Most of them work in projects during their studies with temporary and sometimes part-time employment contracts. The staff contains of people with higher academic degrees and bachelor's degree as well as people still studying either rin HAMK or in some other university.

The research projects are funded either by businesses direct or more often by public financiers like TEKES (National Technology Agency of Finland), although in the case of public funding also businesses provide additional funding. The research projects involve the same themes as the education that AutoMaint offers; the development of automation and asset management.

The research unit has two main purposes; education and research. A third task is to educate own students to be capable professionals for the needs of the unit itself. The final goal is that the educated professionals can successfully transfer to the service of the industry and especially to the partner companies. Continuous development of one-self and encouraging entrepreneurship are seen important in the research unit. In the regional influencing the research unit works with several interest groups: cities and municipalities, companies, other educational institutions, other units of the own school, business incubators, financiers etc.

INTEGRATING R&D ACTIVITIES INTO EDUCATIONAL PROCESSES

In most of Universities of Applied Sciences in Finland the need for increasing the amount of project based learning has been recognized and a lot of efforts are put to change the way of thinking and teaching. Some of these have started to add project based learning to their curriculum by first using mainly internal projects and then increasing the business based components to their projects as the students are getting more professional skills. Finally – in this model – the final thesis is almost always business based. Another approach is to concentrate more to business based projects. Companies are asked to "give" suitable project ideas for different courses. In some cases the same project ideas are used yearly for new groups thus giving alternative solutions to the original challenges. This model also aims to finally offering the students a real business based final thesis.

In our approach the R&D activities are based on active work in business interface. We continuously communicate with the companies in the region and discuss about their problems and development needs. Then we choose the suitable components from our "toolbox" to solve them. The toolbox contains several tools from student projects to building larger project packages together with other companies and universities having same kind of challenges and working also to get funding for this. The fundamental difference in this approach compared to the others described is that the processes are totally focused on the needs of the companies. Our main goal is not just to find suitable projects for our courses. Instead of that we actively try to co-operate with companies and then find or develop new tools to help them. To be able to work this way we need also our own R&D personnel to work with projects which for some reason are not suitable to be totally accomplished by students.

The structure of our R&D processes is described in figure 1. In our new R&D method employees have different roles. Activators are working in the customer interface trying to find new customer oriented innovation ideas together with companies. Project planners know funding instruments and they are

experienced of writing applications. They are also very familiar with the know-how of whole personnel. R&D-personnel take care of research work, but they use, for example, professors as a consultant or expert when this is needed. Arrangement helps all employee groups to participate in R&D-work and improve learning methods and content of courses.

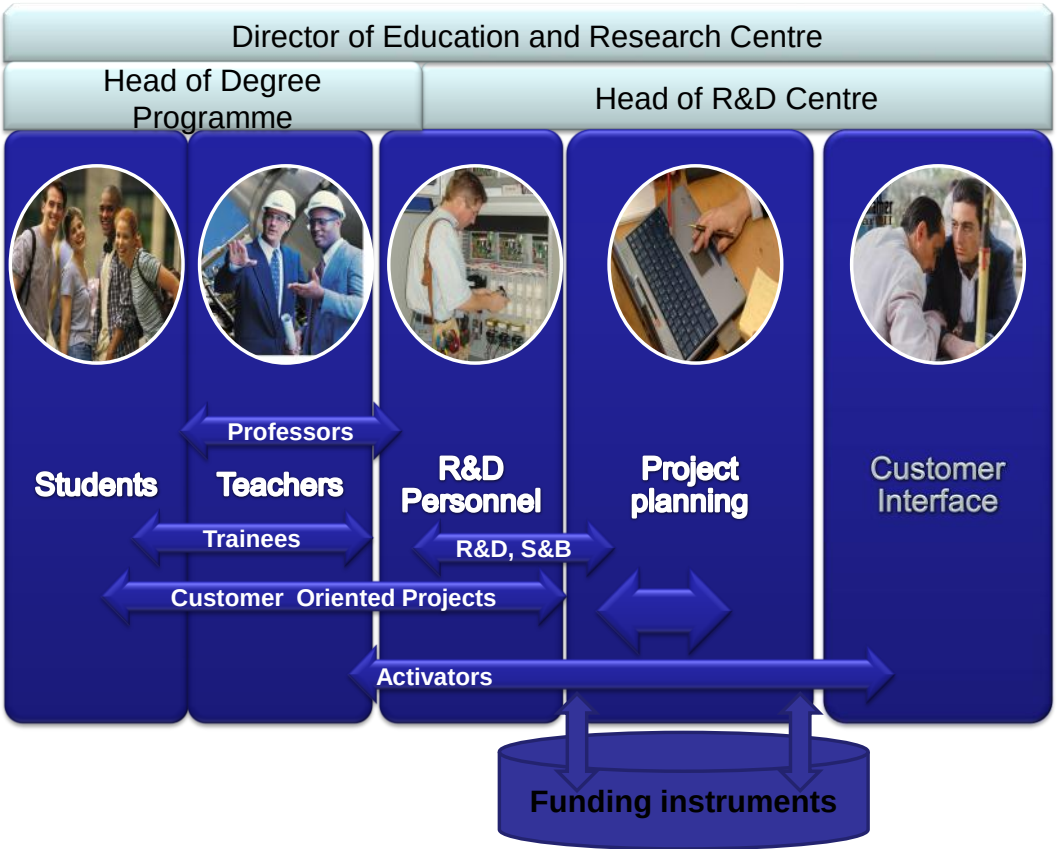


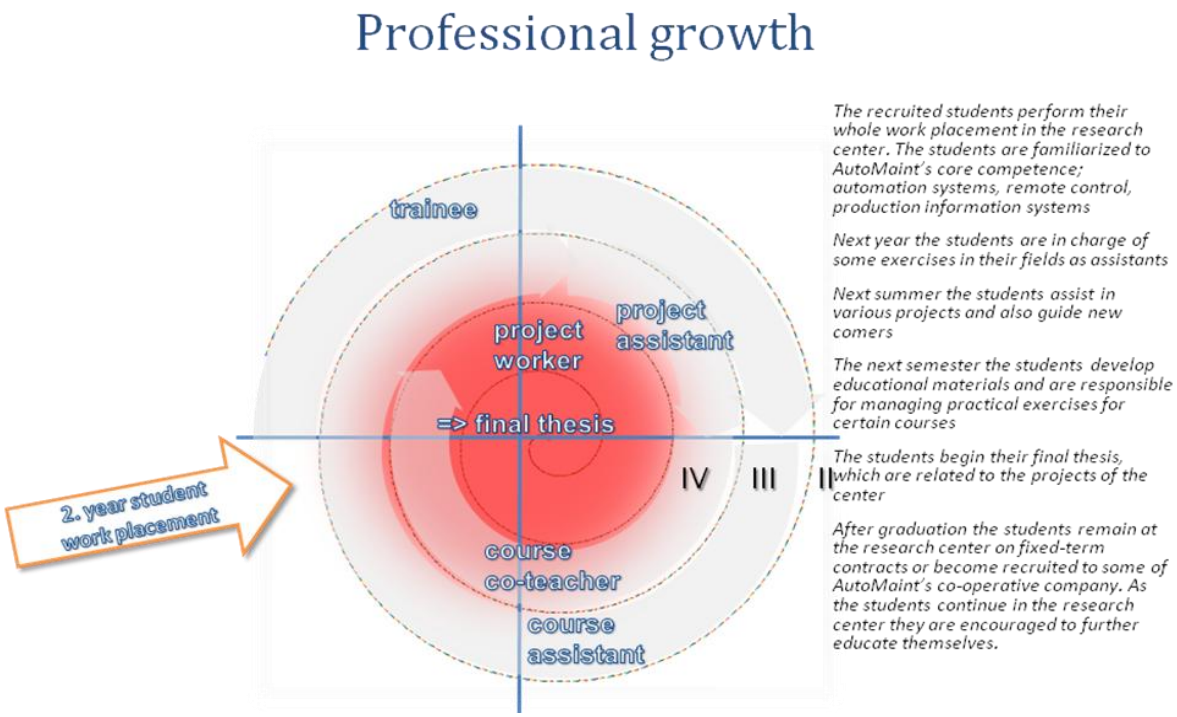
Fig. 1. The structure of R&D processes in active co-operation with local companies

PROFESSIONAL GROWTH OF A RECRUITED PERSON IN THE RESEARCH UNIT

The research unit recruits students every year. In addition the unit commissions also several final theses are done every year to / by the research centre and its customers.

The recruited students perform their work placement in the unit. The work placement period lasts for six months. During this time the student / employee is familiarized with the central areas of know-how, software and tools of AutoMaint. First the students work under guidance of the more experienced workers and later more independently on a project. The projects usually are related to planning and designing the control of an automation equipment, the implementation, data collection, remote diagnosis and control. In the end of the project the employees make a report on the project and present their work. The learning environment of the unit is developed according to the work, equipment and materials. During the next year of studies the students that have worked for AutoMaint, work as assistants along with their studies. In this way they can immediately make the most of what they learned and they know the challenges of the beginners through their own experiences. The following summer the assistants work again as full time workers and they usually participate in research projects and in guiding the new comers. The assistant can already be given more responsible and demanding tasks and they can deepen their knowledge on the field.

During the next semester the assistants are involved more in developing the learning materials and projects. They can also be in charge of some practical cases in some courses. In addition to that they are in direct contact with the companies involved in for example some exhibition events. During the semester the assistants start their final theses which are somehow connected to the research activities and projects of the unit. This way they have a chance to deepen their know-how and concentrate on a specific problem which arises from the needs of a partner company. Usually the students are directly in contact with the company and thus are also partly responsible of the result directly to the company. This gives the company an opportunity to follow the professional growth of the student and at the same time search for a solution for the question at hand. In figure 2 the professional growth of the student researchers offered by the research centre is shown.



Fig, 2. The professional growth of the student researchers offered by the research centre

After graduation the person can continue in the research unit or in some cases in the partner company. When continuing in the research unit, the person is given a chance to specialize and take responsibility of a specific area of education and training. However there are still responsible persons in the permanent staff for each area of expertise. A significant addition to the learning process is the international atmosphere in the unit. Every year 10-15 foreign trainees work in the unit (making a thesis etc.). The unit works with multicultural teams by enforcing project work through the basis of problem-oriented learning.

BENEFITS OF THE SYSTEM

Student

From the students point of view this system enables a more individual curriculum in a way that also concentrates to the main focus of the research unit. In this way the performance can be guided individually. This requires also independence and initiative from the student. This means that the student can complete courses so that they are tied to the research projects in which the students work for. Working with real problems allows the student develop professional abilities [1]-[7]. This way the students can achieve several years of work experience already during their studies from the research unit. Since the research activities are concentrated in applied research, the work experience supports the students' settling to the service of the industry. During the work period the students improve also their team work skills and learn to work in a multicultural team as well. This arrangement also improves the motivation towards studying because the students are able to see the opportunities that they have after graduation and enable the students to reach their goals. Usually the students graduate in time or even earlier than others. The students will be encouraged to continue their studies in which case the student can continue as a part-time employee in the unit. The students are also encouraged to entrepreneurship which is supported by the close relation to the business incubation operations and to the Valkeakoski region development company. The students working in the research unit are also paid, which helps them to finance their studies.

University

The aims of this arrangement are quite same in small scale as in many large education programs, for example more collaboration with industry, more industry-oriented courseware etc. This arrangement provides also many benefits to the school. The personnel structure of a University of Applied Sciences is often very teacher centered. Thanks to this kind of arrangement, the structure can be developed towards a team organization. This forms so called skill-teams including teachers, researchers and assistants. There are also some direct financial benefits. The know-how of the teachers can be utilized directly in the research projects, guiding and planning the education while the assistants concentrate in controlling the practical exercises. The system enables problem-based project learning. This can be implemented from the practical needs of the industry. Through the training of the assistant the learning environment of the school can be developed and take into use new programs and equipment as efficiently as possible. Along with the growth in know-how the unit ensures new project agreements and credibility in the eyes of financiers. Businesses can be offered more charged services. For international exchange the research center works as a central place. The incoming foreign trainees are usually placed in the research center, where they can do their work placement or do their theses which are connected to the research projects of the unit. To the more experienced staff the research gives a chance to develop their own knowledge and bring their information up to date. This often leads also to post-graduate degrees and so the education level of the whole staff rises.

Partner companies

In companies point of view this arrangement increases services appointed towards them. The company can quickly and flexibly get help for solving their minor problems. On the other hand, through the research unit's projects, companies can reach the most up-to-date information of the field, which they can apply quickly in their own activities. Especially important factor from the company point of view is the opening of a significant recruiting channel. Companies can get familiar with experts working in different projects and get the possibility to observe their progress. In some cases the needs of the company can be taken to account already when planning the courses. If, for example, the company already knows that it will need experts on Siemens, the training of automation controls in certain groups can be focused on the products of this supplier. Thus, the company can get specially educated experts on a broad basis.

FUTURE WORK FOR AUTOMAINT

AutoMaint has been working for eight years with the above-described way. The research centre has successfully met the stated objectives and is a way for developing the functions of the University of Applied Sciences, in which the connection between research and education wants to be improved. At the same time the unit is a place where problem centered project learning can be genuinely used in multicultural teams. The main disadvantage in the way AutoMaint is working is the limited number of students participating in research activities. The next clear step is the use of larger student groups in research activities.

Since AutoMaint – and HAMK in general – already has a lot of experience in combining R&D activities into learning processes, the step towards more project based learning is an extend that can be taken. Of course, changing teaching from conventional methods to business based projects changes the role of the students and teachers quite totally. When working as project teams the teacher no longer knows beforehand what will happen. Also the teacher more often has to face situations, where additional knowledge or experts are needed to solve the problems in projects. The role of the teachers will be more like a coach than a traditional lecturer. Of course all this also requires the students to be very motivated, since they have to solve problem and challenges by them self or in team – of course supported by teachers, assistants, and other teams. Also curriculums have to be modified to more support larger projects instead of small – much too often separated – courses.

INNOSTEEL

The other example – InnoSteel – is based on a different approach. HAMK in co-operation with industry and with public funding has developed a new way to improve the know-how in the area of local metal industry. From HAMK's perspective InnoSteel consists of a group of applied research projects, which are mainly focused on local small and medium sized enterprises on metal branch. In addition to the projects InnoSteel contains a training factory managed by a non-profit company - InnoSteel Factory Ltd - owned by HAMK, local cities, schools and a group of local companies. In general InnoSteel is a central node of a large network, thus providing a wide interface for industry focused challenges and projects for teachers and students of HAMK.

The main goal of the InnoSteel project consortium is to increase know-how in companies and educational facilities related to the metal industry. The InnoSteel Factory -training factory is the heart of a diverse research- and learning environment, with the factory being a modern metal engineering workshop with training-, research-, and production capabilities.

One of the concepts in InnoSteel is the virtual learning environment InnoSteel - Virtual Factory. The core of it was created in HAMK's research project, which contained co-operation with several companies and aimed for using different tools and environments to create interactive e-learning materials. At the moment Virtual Factory is an e-learning environment mainly based on simulation and modeling. The whole package is based on the idea of creating a virtual model of the InnoSteel training factory. This has been accomplished by creating separate simulation models of the manufacturing equipment of it and then finding ways to integrate these models. Virtual Factory works in two environments: the full simulation models are used in Virtual Factory classroom and the distance learning part, which is a slightly simplified, has a web browser based user interface for using the simulation models in classrooms server and it can be accessed via the internet.

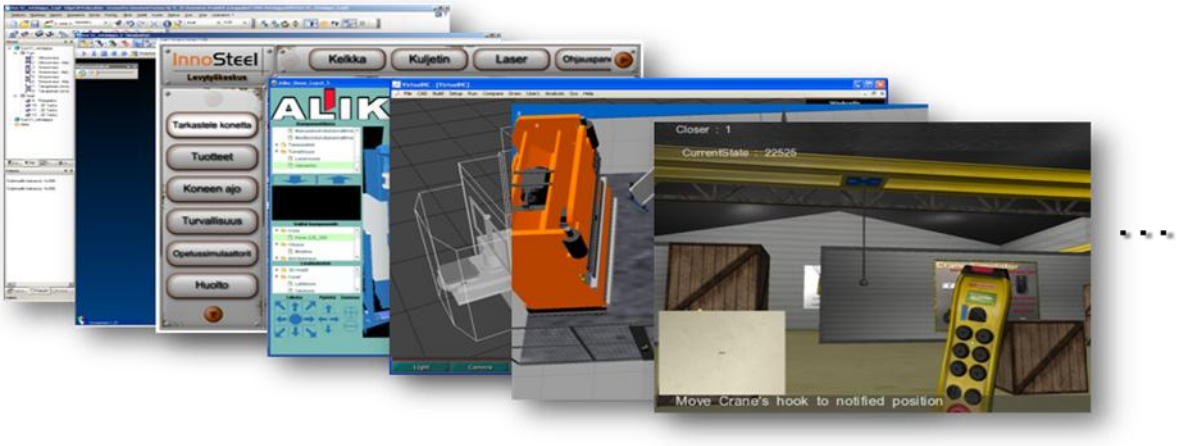


Fig. 3. Examples of the InnoSteel virtual learning environment – Virtual Factory

E-learning materials have to justify their existence by offering clearly something more than the traditional, text based contents. This means naturally that useful e-learning environments should not be created just by transferring the information from books to computer screens. E-learning has to offer experiences and clarifying examples to students to motivate them to continuously develop their skills and knowledge. Since e-learning is meant to be - at least partly - dependent of time and place, the materials have to offer a quite extensive collection of on-line support and background information for the student so that the studying process will not be interfered by lack of information. [8]

Practicing manufacturing skills in Virtual Factory environment is based on using three different approaches to production and being able to mix them together when it is considered necessary. The student will get the first contact to Virtual Factory in web based laboratory demonstrations and learning materials. The materials will typically be small simulations of the real devices in the training factory. This enables the students to well prepare on their visit to the laboratory. This also will save time, since the students will not use the computers in the training factory for learning how the machines work. Instead of that the students – if they really are well-prepared – can quite soon start designing products, which can be manufactured in the training factory.

InnoSteel offers training in several ways. The two main concepts are the use of the training factory as a real life laboratory and a place to do real activities connected to InnoSteel Factory's sub-contracting and research oriented processes. To insure that the students are well prepared to these contact activities, the virtual learning environment – Virtual Factory – is actively used.

CONCLUSION

One of the main objectives of the research center in a University of Applied Sciences is to develop operations based on industrial needs enhancing students' professional growth. Learning is executed by doing. An important part of this doing is guiding others. Guiding practical exercises is a vital part of assistants' own learning process. Connecting research activities to the students' professional growth is the best way to harmonize the interests of the companies and educational institutions.

The research center needs to have a contact interface with students also considering recruitment. R&D–operations act as an interface between HAMK and business, through companies' future needs can be sensed. Thus R&D must have a guiding role when designing new study plans.

Through the teaching offered by the research center, the connection between research and education is best executed as well as the transfer of research data into teaching. The research center can also have a significant role in learning environment development.

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