Technology transfer in a globalised world: transferring between university and industry through cooperation and education

Finn Kjærsdam

Aalborg University
Aalborg, Denmark

ABSTRACT: The transfer of knowledge from university to industry can be facilitated by a set of tools for direct cooperation, a well as by advanced Problem-Based Learning (PBL) based on unsolved problems from industry. It is evident that many companies are interested in such cooperation and are prepared to pay for it. It is also evident that both traditional and PBL education can provide graduating engineers with high competences in science, engineering and technology. However, PBL education gets close to twice as many high marks from companies when it comes to competences that facilitate technology transfer, such as contacts with industry, cooperation with companies, innovation, creativity, project management, human resource management and competences in economy and business.

INTRODUCTION

The transfer of knowledge between university and industry can be carried out through cooperation as well as education. Transfer through cooperation can take place through a palette of tools, such as the following:

- Strategic cooperation;
- Co-financed projects;
- Research parks;
- A portfolio of patents.

The transfer through education can take place by teaching the student new relevant theory and technology unknown to the company employing the graduate after leaving university.

In between these elements are learning methods, wherein the student learns to solve unsolved problems in industry while also learning new theories and technologies under the supervision of a university faculty, such as Problem-Based Learning (PBL) and Work-Based Learning (WBL).

Evidence from attempts with transfer of technology at Aalborg University (AAU), Aalborg, Denmark, supports the applicability of such tools. At the same time, a new survey shows that PBL offers much better preparation for graduates for a career in industry than traditional engineering education, in a world that is characterised by globalisation and the fast development of new technology.

TRANSFER OF KNOWLEDGE THROUGH COOPERATION

The comprehensive and effective transfer of knowledge demands a whole set of tools to raise awareness and cover the many different situations in such a transfer situation. Circumstances depend on the subject, the level of technology, the company and its R&D staff, the university and its scholars, and the laboratory facilities.

Transfer Tools

The following transfer tools should be highlighted:

- Strategic cooperation between the university and the company, where long range common goals, tools and financing are preset in a contract by the managements within which researchers can cooperate on actual common projects;
- Networks between strong research groups at the university and companies interested in the same subject, wherein they transfer new scientific discoveries and share knowledge and problems through meetings, newsletters and conferences;
- Co-financed projects of common interest for both the company and the university, including the co-financing of professors and scholars, as well as equipment;
- Common research centres with co-financed buildings, laboratories, researchers, staff and equipment, which mainly emphasise the company's interests in the beginning and the university in the long run;
- Company hotels at the university, where the company, on a temporary basis, can rent office and laboratory space for its R&D staff at the university for the benefit of students' project work and to facilitate informal scholar and staff common discussions;
- Research parks in the vicinity of the university where development divisions from different companies can benefit from each other, as well as from university professors and a common labour market in some sort of a *cluster*;

- Incubators with office space and common meeting facilities and business services where young scholars with bright ideas and little money have a better chance to survive while developing a new company;
- Springboards to test the content and business possibilities of new ideas, as well as courses in entrepreneurship and innovation for senior year students, postgraduate students and young academics;
- Access to pre-seed, seed and venture capital to develop a promising discovery or invention into a new product and/or business;
- Legal excellence in the negotiation of contracts, patents and licences at the university to facilitate cooperation between the companies and the university at a professional level;
- Managerial excellence in administrative and technical matters in order to facilitate the setting up, application and management of large projects in cooperation with companies;
- The exchange of experience through personal mobility for faculty and staff, as well as membership of each other's boards, steering groups and industrial and research advisory committees.

EXPERIENCE WITH TECHNOLOGY TRANSFER THROUGH COOPERATION

Over the past 15 years, Aalborg University (AAU) has developed the tools described above. The AAU started with the inauguration of Northern Jutland Research Park (NOVI) in 1989, which was set up as a private company in a cooperative venture between the University, the county, the municipality and public utilities. The research park can host R&D staff from private companies provisionally, often in research groups, including several companies that are interested in the same technology.

Cooperation between the University and the research park also includes joint companies that have been established to attract pre-seed, seed and venture capital for promising new patents and innovations from the University. Cooperation also extends with the establishment of company and University hotels where University activities are integrated into the research park and where business activities are integrated into departments of the University.

In recent years, cooperation has included the establishment of incubators for new graduates who want to establish their own company with the following assistance:

- Support in financial, legal and business matters;
- Tutors with experience from businesses to coach and supervise;
- Other academics in the same situation for mutual support.

There are three incubators currently established with the following foci:

- Electronics and IT (Ignition Camp);
- Biotechnology and health (Health'n Tech);
- Design (Dreamhouse).

In this connection, the AAU has also established springboards where new graduates can present their ideas and business plans to experienced businesspersons to garner an immediate reaction and critique, as well as courses in innovation and entrepreneurship.

Since the establishment of the research park, its activities have grown dramatically. Companies in the research park have grown from 10 in 1989 to 65 in 2004, and the number of square metres has grown from 5,500 to 29,000 in the same period.

The next step was the establishment of Technology Transfer Networks as a type of affiliation programme between private companies and university researchers in research areas of common interest, starting in 1996 and growing since then. In 1997, there were less than 100 companies participating in five networks; this grew to 4,542 companies participating in 32 networks in 2002 (see Figure 1).

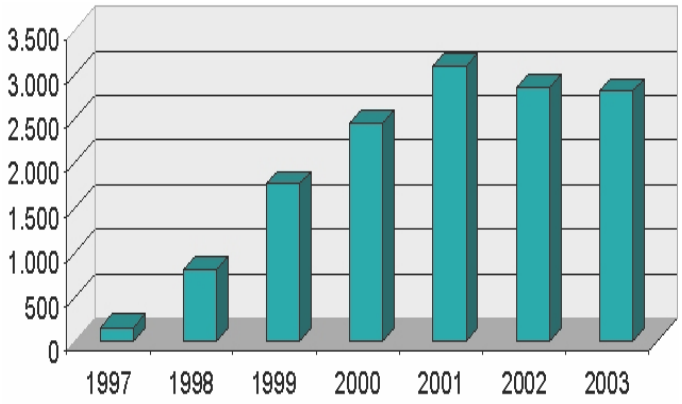

Figure 1: Members of Technology Transfer Networks at Aalborg University [1].

The activities of the networks have increased, along with a rising number of participants. As a measure, the number of newsletters distributed from the networks was less than 1,000 in 1997 and grew to 31,400 in 2002.

In the late 1990s, the AAU started with joint research centres, as well as co-financed research projects between private companies and the University. These centres and projects often have a mid-term range in time and research goals that participating companies find a bit too long and *long-haired*, yet the researchers find a bit too short and un-theoretical. However, that is the point: to extend the technological views of companies and to focus University research on themes that are relevant to the participating companies. The common projects include the financing of 55 researchers, the exchange of staff between the University and companies, and the financing of 55 pieces of laboratory equipment for the use in a joint project or centre within the project period, and for students and University research after the project.

The results of these activities can be seen from the development of the resources for research. This includes business related scholarships for PhD students, where the contribution from private companies to research at the University has more than doubled from 1999 to today, which runs contrary to the AAU's public founding (see Figure 2).

Over recent years, the University has established a unit for patents, as well as legal and contractual matters, in order to support researchers in their cooperation with private companies. This unit can relieve the administrative pressure on the researchers and ensure that the University's rights are

protected in negotiations. The AAU has also established a unit to support researchers in the setting up, application and management of large international research projects between universities and private companies.

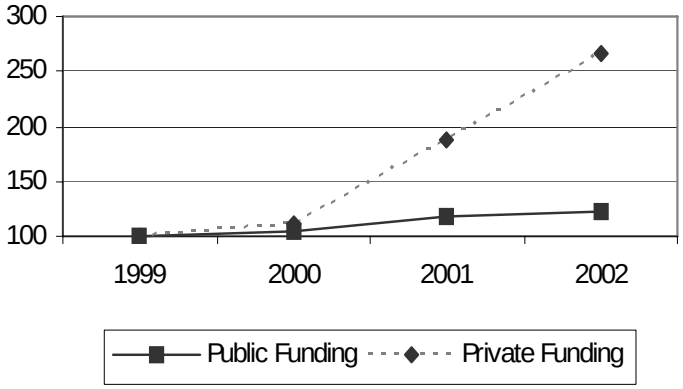

Figure 2: Research funding at Aalborg University [2].

Finally, the AAU has initiated negotiations with the management of some private companies in order to establish long-term strategic cooperation where the AAU has preset common strategic research goals and common tools and financial possibilities. Afterwards, researchers can use these tools and financial possibilities when they want to cooperate at a later stage to reach common goals.

TRANSFER OF KNOWLEDGE THROUGH EDUCATION

In the transfer of knowledge from university to industry through education, there is a set of demands that can support graduates as carriers and developers of new theory, methodology and technology that would be otherwise unknown to a company. These demands include faculty, curricula and various learning methods.

Among those demands are the following:

- Research-based education where faculty members are active researchers and where faculty members know the frontier of knowledge in their subject and produce new knowledge;
- Curricula that ensure that students learn the latest theories, methods and technologies at a level of interest to the participating companies;
- Curricula that ensure that graduates acquire competences and new knowledge themselves, as well as through cooperation with colleagues and through common project work;
- Curricula that ensure that graduates gain competences for communicating new knowledge and technologies to management and colleagues, as well as customers;
- Curricula that develop and instil creativity and innovation in graduates to qualify them to find new and better solutions to problems that they are working with;
- Educational methods that support the exchange of problems and knowledge between the University and industry so as to ensure that the theories, methods and technologies the students learn are relevant;
- Further education, as well as education on demand, for employees in companies who wish to introduce new technologies and products.

EXPERIENCE WITH LEARNING METHODS SUPPORTING TECHNOLOGY TRANSFER

A learning method that can fulfil these demands is Problem-Based Learning (PBL), wherein students learn through a process of trying to solve real problems in industry under the supervision of a faculty member from the University, who acts as a supervisor and coach. This is supported by courses on theory and technology related to the problem that students seek to solve. The learning process and technology transfer can be strengthened if the student has an experienced co-supervisor from the company who is prepared to learn new theory and technology, to discuss the implications of these with the student and the university supervisor and to help the student with knowledge about the company and the problem at hand [3].

Denmark is, in many ways, a laboratory where PBL's success can be verified. The two main technical universities have had the same status and economic possibilities, but different modes of education over the past 30 years. Aalborg University (AAU) has educated engineers based on problem-based project work [4]. On the other hand, the Technical University of Denmark (DTU), Copenhagen, has educated engineers in a more traditional manner using lectures that have been supported by laboratory work and projects.

The verification of PBL's success can be answered by a new extensive survey that was recently carried out by the independent consultant, Opinion Analyse Institute (IFO), in cooperation with the magazine *Ingenioren*. The directors of human resource management in the 487 Danish companies surveyed, which employ most of the engineers, were asked to assess the qualifications of engineers graduated from the two universities and to compare these with the qualifications that these companies found most important in a world with exponential growth in new technology and global competition.

The survey revealed that 87% of the companies accorded the PBL education system (AAU) high marks (good or very good), while the more traditional educational approach (DTU) obtained high marks from 74% of the companies. This is shown in more detail in Figure 3.

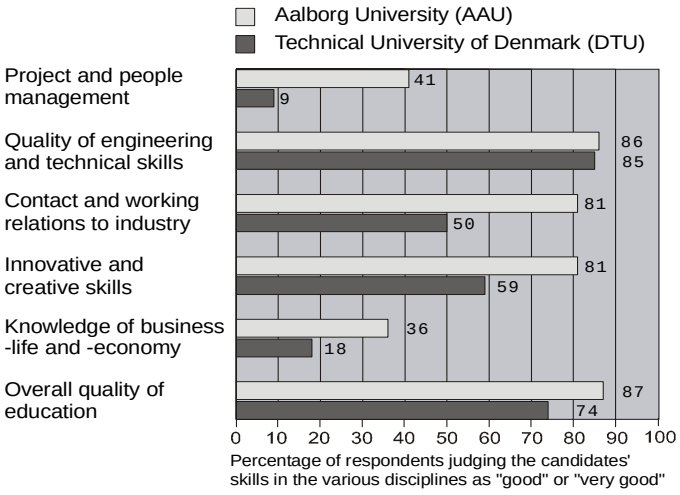

Figure 3: Graduate engineers assessed by industry as being either good or very good [5].

The reason for this difference is not so much differences in the students' level of knowledge in science, engineering or

technology, where both universities have scored high marks. However, in all other respects, the PBL education system gained much higher marks than the traditional educational system. This provides strong evidence supporting the PBL education system at the AAU.

PBL graduates' contact and cooperation with industry were given high marks by 81% of the companies surveyed, while traditional education was given high marks by 50% of the companies questioned.

In innovation and creativity, PBL education scored high marks by 81% of the companies surveyed, while the traditional education format received high marks from 59% of the companies surveyed.

There was a dramatic difference between the two education formats with regard to competences in project management and human management. PBL education was conferred high marks by 41% of the companies surveyed, while traditional education received high marks by only 9% of companies involved in the survey.

Finally, the difference in competences in business and economy was also found to be dramatic, even if competence in this area was assessed low for both universities' education systems. The PBL education secured high marks from 36% of the companies surveyed, while the traditional education format was accorded high marks from 18% of the companies.

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