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Promotion of Cooperation in Research and Development Between Universities and Industry in the Czech Republic

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Universities must react to the situation in industry, increasingly oriented towards sophisticated technologies. Grant applications submitted together with industrial companies, direct support of applied research by industry, integrating students into applied research, project-oriented education, all these ways help to bring universities closer to the needs of industry. Supporting collaboration between universities and industry in the Czech Republic is briefly reviewed in the paper.

Key words: applied research, technical universities, industrial companies, cooperation, support in the Czech Republic.

1. Introduction

The traditional model of an industrial company has changed considerably in the last decades. Heavy industry "dinosaurs" have lost their key importance, which has passed to firms producing more sophisticated technologies. Both engineering education and research at universities must react to these developments. If this does not happen, there is a real danger that technically-oriented universities will lose their position to other forms of education, carried out by industrial companies and various private schools and courses, which are fitted closely to the needs of specific branches of industry. Applied research and development should form one of the main activities of universities and their faculties oriented to engineering, and this should also be reflected in the educational activities. If it reflects the needs of industry, it can be an important contributor to limited budgets of universities, but, which is even more important, it can substantially contribute to spectra of themes of projects, in which advanced students can be involved. In this way, engineering education at universities can be closer to the real life, and prepare graduates for "swimming in the waters" of industrial practice.

2. Problem of mutual understanding between universities and companies

Expectations of companies and academic institutions concerning research and its results are often different. Universities usually prefer long term fundamental research guaranted by stable financing. In many countries, the Czech Republic including, their research is evaluated according to the number of publications, impact factors of journals, in which their results are published, a number of citations and h-factors of their academic employees. The number of Nobel candidates among the staff or graduates might be an interesting contribution to the prestige of the university. However, no one of these criteria is interesting for industrial company.

Industrial companies in general are not interested in topic scientific results with the long way from investigations to practical applications. They live in the highly competitive environment and, therefore, they must innovate their products as quickly as possible, as they need to have applicable results earlier than their rivals. Economical aspects of the proposed innovative solutions play also a crucial role. The management needs to weigh carefully relations between costs and benefits, which determine the success of a particular product in the market.

These often contradictory approaches result in the fact, that finding common language between an industrial company and an academic world is sometimes difficult. What to do with this discrepancy? The approach of technical universities to research is (slowly) changing. They understand that, though fundamental research is prestigious, interesting and important, they need to extend their research activities in the direction to applied research, development and innovations. The field for collaboration with industry is (also slowly) opening. The necessary step in this direction should also be extending criteria for evaluation of universities, and especially of engineering branches at universities. They should not be based nearly exclusively on the publication record. Agreements with industry, patents, prototypes and functional devices, original software written for needs of information and automation in industrial companies should be comparably prestigious outputs.

The usual evaluation of fresh graduates by their future employers is also related to the orientation of their university towards fundamental and applied research. Frequent complaints of industrial managers to their address are: they are very good in theory, mathematics, sometimes also in information sciences, but they are not prepared as well for practical life, they have deficiencies in communication and their practical experience, readiness to solve unexpected problems, is not as high as desirable.

3. Ways of collaboration

The ways of contacts between universities and industrial companies are multiple and range from the simple "head-hunting" and the offer of jobs for graduates to the deep research and educational collaboration. Let us summarize them briefly.

The head-hunting has two forms: The first one is advertising the job at the university, job fairs, etc. This is useful for students and graduates, however it brings nearly nothing to the university. The more sophisticated way of search for good graduates is participation of students in joint projects, and, at a higher level, in joint laboratories. Companies and other external institutions can assign the themes of student research works and theses at various levels of courses from the bachelor to the doctoral ones, which extend the offer of topics and are supervised jointly from the university and from the external institution. The research task linked this way to the practice helps to students in understanding real problems, and moreover, they often find a future job this way and are for it better prepared. A pre-condition for achieving this goal is to change the old fashioned mind sets of both some academics and some industrial managers.

The most direct form of research collaboration is commission of some research work by a company. Such research needs to be and usually is narrowly targeted to a particular problem, which cannot be solved by the own research capabilities of a company. If such order is a part of wider contact between both institutions, it enhances not only the budget of the university, but also its practical abilities. However, because of time limits for such work, it is often impossible to use it as a theme for students' theses. Moreover, the bad habit of some companies is that they want to avoid payment of overhead charges to the university and they contract directly with members of the university staff. On the other hand, the bad habit of some universities is that they ask for so high overhead that it makes them not competitive in the market.

Direct forms of collaboration can relate also to education. External lecturers from various institution including industrial companies are a welcomed enhancement of courses especially for advanced students. On the other hand, companies can ask for and realize life-long learning courses tailored according to their needs.

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However, universities are usually more obliging in this way of collaboration than companies, as education is one of their primary missions. Releasing workers temporarily from their working tasks due to their engagement at the university as lecturers in regular courses or as students of life-long learning courses makes sometimes problems in those companies, in which the management is oriented more to the immediate profit than to the future.

Joint laboratories of universities and technologically advanced companies are probably the best way of collaboration, which is long lasting and profitable for both sides. They represent useful material basis for joint projects and stronger financial possibilities of a company give good possibilities to equip the laboratory by up-to-date instrumentation and devices. As a benefit for a company, students familiarise themselves with the company and its products, and therefore they tend to prefer these products in their future jobs.

Finally, the joint grant projects are the main tool for supporting collaborative research of universities and industrial companies by the state authorities and the state budget in many countries including the Czech Republic. Specialised grant agencies operate usually in this way, in some cases subordinated to various ministries, in some cases independent and subordinated directly to the government. The Czech Republic has two main grant agencies, the Grant Agency of the Czech Republic (GA CR), which supports fundamental research projects, and the Technology Agency of the Czech Republic (TA CR), supporting applied research and innovations. Let us deal by the Technology Agency of the Czech Republic as an example of good practice in this field.

4. The Technology Agency of the Czech Republic and university-industry collaboration

The mission of TA CR is expressed in its documents [1] as follows: "The Technology Agency of the Czech Republic (TA CR) is the main organisation which implements the state policy in the sphere of applied research, development and innovations. The mission of the TA CR is to create and implement effective and transparent system of applied research, development and innovations support to the whole extent thereof. The TA CR participates in the conceptual orientation and creating of research environment of the CR, in the preparation of National Policy of Research, Development and Innovations, produces strategic documents in the field of applied research, development and innovations and implements key programmes in this field, in particular based on national priorities of oriented research and development. The Agency performs analysis of results and data received from its activity and provides them for the needs of further course of applied research, development and innovations. It comes from and develops international cooperation with partner agencies of applied research. The TA CR cooperates upon the preparation of programmes with other sectors and providers of support in the field of applied research, development and innovations and promotes its activity by effective cooperation among research organisations and application sphere and contributes to the attainment of strategic economic and social goals of the Czech Republic while respecting the sustainable development principles."

When passing through the programmes of TA CR for supporting applied research, development and innovations, we can notice that they give wide possibilities for joint projects of industrial companies and research institutions (universities in the Czech Republic are from the point of view of legislation included among research institutions), and rules of some of them even ask for such collaboration as the compulsory condition.

The ALPHA programme has been very interesting for technical universities, as it has aimed to support applied research and experimental development especially in the field of advanced technologies, materials and systems, energy resources and the protection and creation of the environment and the sustainable development of transport. The relevant outputs of this programme are patents, pilot operation, proven technology, results with legal protection, i.e. utility models, industrial designs, technically realized results, i.e. prototypes, functional samples, certified methodologies and procedures, maps with expert content and software [2]. This means that the recognized outputs from the point of view of evaluation of the results reflect needs of collaboration of academic sphere with industry. They might be less accustomed for some research departments at universities, for which publications in scientific journals with high impact factor are the most frequent and most relevant outputs. The ALPHA programme ends in 2016, but it is replaced by the very similar EPSILON programme, which will extend for further 5 years. Expenses of research institutions, including universities, may be covered fully from the grant, whereas industrial companies must contribute 20 to 75% (depending on their size and the character of the project) from their own sources.

Similar conditions are also in the other programmes. The Competence Centres programme supports the establishment and operation of large (virtual) centres for research, development and innovation with many participating institutions. Compulsorily, at least one research organisation must be a member of a consortium, therefore the wide area for participation of universities opens here. Emphasis is placed on the innovative potential of the projects and the sustainability of the research agenda of the competence centres.

The programme GAMMA is one step closer to the immediate needs of industry, as it aims to support the verification of results of applied research and experimental development in terms of their practical application, and to prepare their subsequent commercial use. It has two sub-programmes: In the sub-programme 1, recipients can only be research organizations, industrial companies are collaborators. Sub-programme 2 is aimed at supporting projects leading to direct commercialization of the achieved results. Recipients can only enterprises, research organizations may participate as other project participants.

The other programmes are rather specific: The main objective of the programme OMEGA is to strengthen research activities in the area of applied social sciences. Therefore, the relevant outputs are adapted to this type of sciences. Universities can take part in this programme, however it is of minor importance for engineering. The programme BETA is oriented to the specific topics and issues that state authorities want to address in the area of research through public procurement. And finally, the programme DELTA supports mutual collaboration with foreign institutions and companies in the framework of agreements with similar agencies as TA CR abroad. As it is oriented only to a few selected countries, it is usable, but it is not a matter of preferred interest for universities.

The programmes of TA CR are useful tools for strengthening applied research, development and innovations in the Czech Republic and for promoting mutual collaboration of universities, and especially of technical universities and engineering faculties, with industrial companies. Nevertheless, it is possible to see three serious shadows in this system. First of all, the Czech science is sub-financed and the hunger for financing projects from the programmes of TA CR is enormous. The budget of TA CR is lower than desirable and does not allow the satisfactory success rate. The second problem is more or less general for most of grant competitions, especially for those, in which organisations with different legal statute take part. The rules must be in the necessary conformity with the legal system for all types of organisations, which are recipients of grants, and therefore, the administrative load in projects is enormous. And finally, as in many grant competitions,

the problem of highly qualified reviewing is substantial. Reviewers are chosen by a lot from the database of specialists. The possibility that the particular reviewer is more demanding that the others, or even that he has some relation to the rivalrous company, and therefore he gives a bad rating to a project, is not negligible. And as the success rate is low, one "unfriendly" review means usually that the project has no chance to be accepted and financed.

In addition, some Czech ministries have their own programmes supporting applied research and development (e.g., the Ministry of Industry and Trade, the Ministry of Culture, the Ministry of Environment). Come collaboration can also be covered by programmes financed from European funds, but the majority of state support of applied research, development and innovation goes through the TA CR. For the better picture, the TA CR budget in 2015 was nearly 3 milliard CZK (about 110 million EUR), and 1 125 904 700 CZK, i.e., more than one third of this budget, was transferred in grants to universities.

5. Conclusion

In the modern world of sophisticated technologies, technical universities with ambitious engineering programmes should play an increasing role. However, the young generation is interested more in soft sciences. The extensive production of "managers for everything" has become a significant characteristic even at some faculties and universities specialising in economics and management, and the labour market sometimes has difficulties in absorbing them. Advanced engineering education needs to arouse more interest of graduates from high schools. Increased research collaboration with industry, leading also to creating more highly qualified and well paid jobs, can help the technical universities to convince potential customers, i.e., young graduates from high schools, about attractiveness and usefulness of engineering.

However, the key importance of academic world is that it is an important factor moving industrial technologies and quality of life forward. It is needless to say, that as the secondary effect it also helps to improve both practical competences of universities and their budget, and contributes to their equipment with modern instrumentation, software and methods.

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The Vital Collaboration of Industry and Academia for the Creation of Interdisciplinary Real World Student Projects

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The global economy in which engineers live is in constant change and evolution. The requirements for engineers today includes not only solid technical knowledge but also require they know how to apply that knowledge to real world problems. For these reasons, engineering education must reach beyond the academic world and draw in industry. The real world experiences that engineering students must have to be effective come from industry and not the more research oriented university environment. This paper reviews what avenues are available to enrich and grow the university/industry relationship and in particular, this paper describes an approach successfully implemented in the U.S. of industry sponsored and driven, final year, interdisciplinary, year long, capstone projects.

Key words: interdisciplinary approach, engineering education, university/industry relationship.

Industry Involvement in Education: There are several avenues for industry and universities to build strong relationships with each other:

1. Industry commercialization of university created technology and intellectual property.
2. Joint research either sponsored by industry or by external organizations such governmental agencies.
3. Participation of industry experts in university curricula as instructors and guest lecturers.
4. Support for updating of laboratories and university resources.
5. Challenging internships for students within the entreprise.
6. Creating projects for students through the curriculum that support the learning process.

In these last two categories, the incorporation of real world projects and experience coming from industry into technical engineering curricula provides a unique and invaluable enhancement to the educational experience. Specifically the inclusion of projects into the curricula supports the pedagogical philosophy of Project Based Learning (PBL). PBL is one of the modern technologies that universities in many parts of the world are adopting to develop engineering graduates capable of being the practical, application oriented, problem solving engineers needed in industry. This pedagogical approach is well established and has been reviewed extensively [1, 2, 3].

PBL is being implemented in a variety of different ways depending on the curriculum and the surrounding economic climate. Essential characteristic of projects within PBL are that the projects are central, not peripheral to the course, they are focused on a driving question, they require transforming acquired knowledge, they are largely student controlled, and finally are real world problems [1]. One of the very successful approaches has been the tackling of projects that have a value to local industry. Industry sponsorship brings industry into the educational process in a vital and important participative way: the projects are real world problems, the

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