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IMPACT OF COOPERATION BETWEEN UNIVERSITIES AND INDUSTRY ON CIVIL ENGINEERING CURRICULUM OF STUDY – EXPERIENCE OF POLISH TECHNICAL UNIVERSITIES

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Abstract. The development of a knowledge-based economy requires stronger and continuous cooperation between the spheres of education, science and industry. The universities create their surroundings through transfer of technology and scientific staff, and through graduates preparation. Benefits of scientific institutions, including higher education ones, in this type of cooperation consist mainly of increasing their recognition among employers and candidates for study, improving the quality of education and research, receiving financial benefits and fulfilling legal obligations. As the other main partner, the industry can achieve, among others, the following benefits: improving the quality of human capital, using the university as a source of ideas, promoting the company's image as an attractive partner, creating a network of contacts with the academic environment. Because of the benefits mentioned the relationships between universities and the socio-economic environment are becoming more and more intensive. Research conducted at technical universities always had influence on what and how students were taught. Good and valuable education process cannot exist without the scientific research in the field of study represented. From the other side, there must exist synergy between research and industry, and what is nowadays extremely important, the learning outcomes such as knowledge and competences of graduates, have to fulfill the needs of industry. Some general experiences regarding cooperation between science and industry with its impact on forming the curriculum of civil engineering are presented on basis of bachelor and master degrees studies at the technical universities in Białystok and Wrocław (Poland).

1 INTRODUCTION

In the relation "university - industry", cooperation takes place mainly on two main levels:

- scientific and research cooperation in the following forms:
  - conducting research and development projects, applied by industry in the form of technology,
  - joint implementation of research projects along with raising funds for their financing,

  - performance of technical expertise by university professionals;
- cooperation in the field of education in the following forms:
  - creation of curriculum of study consistent with the needs of business (e.g. by creating desired courses of study, especially of practical profile),
  - participation in launching dual studies, included in the strategy of modernization the higher education (students will be educated both at the university and by the employer, gaining knowledge on the one hand and practical skills on the other one),
  - individual support of the education process (e.g. in the form of providing materials and data for diploma thesis, involvement of practitioners into the teaching process, enabling students to complete traineeships and internships),
  - choosing the best graduates for possible employment in companies.

The enterprises are becoming increasingly active, and they offer universities various forms of cooperation in order to prepare graduates to enter the labour market. The main proposals of cooperation in the field of education are indicated in Fig. 1.

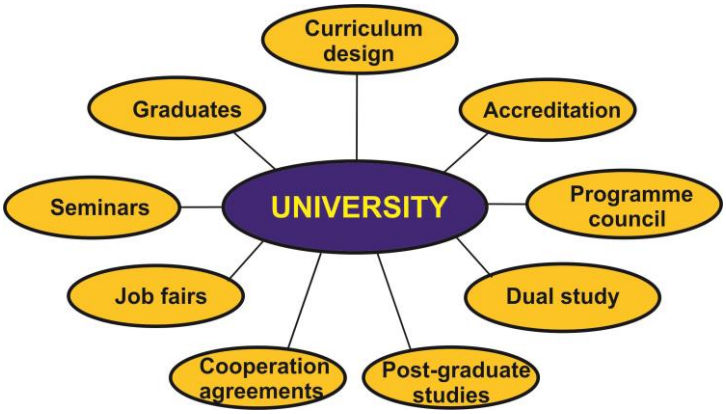

Figure 1: Main forms of cooperation between technical universities and employers in the education area

Some aspects of cooperation between university and industry and its impact on forming curriculum of study in the field of civil engineering are presented on the basis of the bachelor degree (BSc) and master degree (MSc) studies at the technical universities in Białystok and Wrocław (Poland).

2 COOPERATION BETWEEN TECHNICAL UNIVERSITIES AND INDUSTRY IN THE R&D AREA

The development of innovative technologies and the introduction of new products as a result of R&D conducted by the company requires large expenditures on scientific and research infrastructure as well as building specialized competences in a selected area of science and research. Big industrial companies usually have their own excellent research centers in which they employ outstanding scientists. However, in the case of smaller companies, one of the options for the operation of enterprise is to cooperate with scientific and research organizations in order to carry out joint research work or to use already developed research results in practice. On the other hand, scientific and research organizations want the results of their investigation to be applied in industry.

In the area of research, the six main categories of cooperation between universities and enterprises are mentioned most frequently [1]: research sponsorship, joint research, formation of consortia, licensing (technology transfer), creation of start-up enterprises, data exchange. It is worth noting, however, that only the first three forms assume co-operation at the level of conducting research, the others assume sharing of ready-made solutions developed in the course of research. As pointed out by representatives of the largest international corporations, cooperation in the field of research is worth taking even when each partner has the knowledge and resources which enable the project to be carried out independently, because it allows to improve the quality of research, increase their scope, and to reduce of costs. This solution is also supported by the growing demand for interdisciplinary research [2].

For scientific and research organizations, such as universities, scientific and research activity is one of the two basic goals of operating. The other one is education of students. It is obvious that education of students (engineers in the case of technical universities) consistent with the requirements and needs of broadly understood industry, cannot function without the conducting and implementing the research of universities in the areas of education they provide. Only when there is a link between the results of research activity (performed by the university itself or conducted in cooperation with the industry) with the education process, this education can be effective and guarantee the promotion of graduates able to meet the requirements of the labour market.

3 COOPERATION BETWEEN TECHNICAL UNIVERSITIES AND INDUSTRY IN THE AREA OF EDUCATION

3.1 Employers' requirements for graduates of the technical studies

The employers indicate a lot of gaps in the education programme or inadequacy of programme to their specific needs as well to the expectation of the labour market. They underline not enough practical classes and practice acquired in university, the lack of opportunities to acquire the professional certificates during study period, inefficient division of education process into first and second degree, insufficient share of courses typical or fundamental for civil engineering in the whole curriculum of study.

The employers expect graduates to have a high level of competence which is a synthesis of theoretical knowledge, practical skills and personal features [3-5]. In their opinion, the role of the education system is to prepare graduates practically for the profession and to provide them with a wide range of professional skills. The most frequently mentioned weakness of university graduates is the lack of experience and practical skills as well as lack of the ability of analytical thinking, ability to establish contacts, to create a harmonious cooperation, a sense of responsibility etc. Education in the field of civil engineering enables the acquisition of the majority of competencies considered important and useful at work, except for professional experience. The lack of these abilities of graduates creates for the employers the necessity to conduct the adaptation process of a new employee to work in an enterprise which can last from one month to up to three years [5, 6].

A detailed list of the most important competences for employers and those whose graduates are missing the most is given in Table 1.

Table 1: Graduates competencies according to employers

The most important competences for employers	
Effective communication Knowledge of foreign languages Openness to learning and permanent development Involvement in work Ability to group work	Ability to define and justify priorities Ethical behavior as a basis in any activity Responsibility Ability to organize work and effective time management Flexibility and adaptability
Competences with the largest gap in relation to the expectations of employers	
Aability to define and justify priorities Ability to organize work and effective time management Correct self-esteem; understanding personal strengths and limitations	Ability to formulate and solve problems Ability to group work Involvement in work Ability to project management

3.2 Curriculum design

The idea of curriculum based on learning outcomes should facilitate cooperation of universities with external stakeholders in the process of educational offer development. According to current rules, every curriculum, regardless of profile, has to be assessed and accepted by the representatives of employers and professional organizations [7]. However, the cooperation with employers is the most significant matter in case of practical profile of study.

The legislation [7] clearly differentiates the requirements for practical and academic profiles of education, among others, obliging universities to increase, within the framework of practical profile studies, the period of student internships or closer cooperation with experienced practitioners.

Practical profile includes the modules for acquiring the practical skills and social competences. It is implemented with the assumption that more than a half of the study programme as defined in ECTS credits consists of practical classes forming these skills, including those obtained during workshops conducted by practitioners with professional experience gained outside the university.

Academic profile includes modules related to research conducted in the university, carried out with the assumption that more than a half of the study programme as defined in ECTS credits consists of classes for in-depth knowledge acquisition. The solutions should limit the popular fields of study with many graduates whose qualifications do not meet the needs of the labour market, in universities that do not guarantee a high level of education resulting from the lack of specialized academic staff. In addition, following the suggestions of employers in the current rules, the organizational units conducting the studies of practical profile are required to include at least three months of professional internship in the curriculum [3].

In case of universities considered: Faculty of Civil and Environmental Engineering (FC&EE) of Bialystok University of Technology (BUT) and Faculty of Civil Engineering (FCE) of Wrocław University of Science and Technology (WUST) the current curricula of two-level civil engineering studies of general academic profile are mainly based on the knowledge and experience of university staff. However, the guidelines and recommendations from the construction industry and professional organizations were also taken into account. Graduates of the 1st level studies are mostly directed to work in building sites, whereas the

2nd level studies develops the most advanced knowledge and competences, thus the graduates are also predisposed to creative design work and scientific research.

3.2.1 Civil engineering BSc graduate profile and employability

After completing the first level studies in the field of *civil engineering*, a graduate, according to their acquired knowledge, skills and competences, is prepared to be able to: make decisions concerning the design of elements and simple objects of housing and public service buildings, as well as simple industrial and transportation infrastructure. He knows how to implement proper building materials and apply construction technologies. A graduate knows the principles of the strength of materials and structural mechanics and is able to formulate, construct and apply simple engineering structural calculation models. A graduate is able to create and read technical drawings and to recognize cartographic and geodesic elaborations. He knows and applies current building codes. A graduate takes advantage of the latest computer technology supporting the modelling and design of structures, construction processes and also construction works management. He knows the latest design techniques, as well as trends in construction work development and is able to administer a construction site. He knows the performance analysis principles and also the costs and scheduling of construction works. He is able to critically select arguments that support collective decisions concerning task performance in civil engineering. A graduate is able to work in a team and has knowledge and skills in the area of occupational safety and health. He is responsible for his own and other employees safety at a workplace. He is able to complete a report on the course of performed tasks and designs. He is aware of the necessity of continuous job and personal competence development and follows a code of ethics. A graduate of *civil engineering* is prepared to be able to supervise construction sites of all types of structures; to participate in the design of housing and public service buildings, simple industrial constructions and transportation infrastructure and to organize the production of construction elements. A graduate is prepared for work in: construction companies; supervision of civil engineering works; concrete, steel, timber and building element plants; the building materials industry and also governmental and local government administration units connected with civil engineering and architecture. A graduate is able to use a foreign language to at least B2 level according to the Common European Framework of Reference for Languages **(**CEFRL) and is able to use a specialized language within his profession. He is also prepared to undertake the second level studies in the field of civil engineering.

3.2.2 Civil engineering MSc graduate profile and employability

After completing the second level studies in the field of *civil engineering*, graduates, according to their acquired knowledge, skills and competences, are able to make decisions concerning the proper selection of building materials to be used, the design of building objects and also construction procedure. Graduates in today's age know the trends in the designing and preparing the construction projects. They are able to design the complicated building objects, they know advanced structural mechanics, and are able to formulate, create and then apply the appropriate calculation models of complex engineering structures. They are able to make and read technical drawings, to recognize cartographic and geodesic elaborations and also to lead construction works. They are able to formulate and solve new,

innovative engineering, technical and organizational problems related to civil engineering. Graduates can use of computer technologies that support design processes, as well as construction projects. They are able to critically choose arguments supporting collective decisions regarding the execution of civil engineering tasks. They are able to elaborate and publish reports regarding the development of works. Graduates are aware of the necessity of developing professional and personal competences. They follow the code of ethics and know and apply building law regulations. They possess language skills in the area of the scientific disciplines and fields of study adequate to the studied discipline according to CEFR requirements to at least B2+ level. Graduates are prepared to solve complex project, organizational and technological problems; to elaborate and realize research programmes; to undertake actions on an international scale; to participate in the marketing and promotion of building products; to continue their education and participate in research and activities directly related to civil engineering and building materials manufacturing. They are ready to increase their qualifications continuously and to complement their knowledge and also to manage big teams. Graduates have the possibility to start work in design offices, construction companies, research institutes and research and development centres, and also institutions dealing with advisory and knowledge promotion in the area of civil engineering. The second level civil engineering graduates are also prepared to continue their education and undertake the third level studies.

3.3 Dual study

One of the most effective forms of employers' participation in creation a curriculum and in education of graduates for their needs is a dual study. The dual study is an innovative system of study, assuming the acquisition of academic knowledge and practical experience at the same time. The study programme includes the necessary theoretical knowledge acquired during lectures, classes and laboratories/workshops at the university, interconnected with periods of work in various positions in the company, within the frame of a contracted internship. Dual study is characterized by closely linking education with practical activity in the workplace. In this way the theoretical knowledge is immediately put into practice. In order to determine the course of study and professional practice the programme council is appointed in agreement with the professional organizations, which include representatives of the companies and institutions employing students. As a result of extensive discussions the best form of the course is determined. During studies the student learns about the structure and expectations of employers towards their employees. Student working at the plant also prepares interim papers thematically related to his work, and at the end of education he solves a specific problem associated with the plant, in the form of a thesis. The supervisors of the thesis are an employee of the university and a professional representative designated by the employer (with the title of at least MA/MSc). At the end of studies the graduate automatically becomes a potential full-fledged company employee, whose employment does not require any additional training or implementing to the corporate structure. However, the creation of such studies is associated with overcoming multiple organizational and financial barriers by all participants of the project.

3.4 Post-graduate studies

The easier form of preparing graduates for the needs of labour market is conducting joint post-graduate studies by the university and the only particular employer, or employers of a similar profile. The implementation of post-graduate studies is independent of the course of studies leading to the professional title (MA). Classes in the course of post-graduate studies are targeted at the specific needs of the labour market to supplement the knowledge and skills of graduates. The teachers are partially the university staff and partially - practitioners (employees of enterprise). The studies are designed for graduates of first-degree study and can be implemented during the second cycle of study.

3.5 Seminars and trainings organized by the professional associations and employers

The valuable complement to the teaching process is presenting the practical side of the issues discussed. The subjects of conferences and seminars organized by professional associations, and often also by individual employers are beyond the scope of typical curriculum of study. The topics often fill the gap in the typical university education regarding the latest trends in the civil engineering, as well as the specific needs reported by employers, that should be incorporated into educational process for engineers. Particularly valuable element of such training is the presentation of specific case studies, or preparing a lecture based on the own experience of company. Usually trainings and lectures are conducted free of charge.

3.6 Cooperation agreements

In the frame of bilateral agreement the university and enterprise declare their willingness to cooperate in the areas covered by their statutory activities, in all legally permissible forms. Usually the agreement concerns the cooperation for implementation of joint projects in a selected faculty of civil engineering, such as:

- optional (extra) courses for students and teaching staff of faculty,
- outdoor activities - technical trips to building sites ("meeting with reality"),
- scientific cooperation (joint projects, publications, conferences, etc.),
- implementation of practical PhD thesis,
- implementation of BSc and MSc theses suggested by enterprise with the participation of two supervisors (one from university, other from enterprise),
- 6-month internships according to the curriculum of study particularly important for study curricula with practical profile),
- optional internships for gaining practical skills,
- industrial internships for teaching staff of faculty (according to individual applications),
- competitions announced by enterprise for thesis in the specified topic (subject indicated by the company),
- cooperation with the students' scientific teams,

as well as in other areas established during mutual cooperation. Particular activities under the agreement usually depend on the needs of the enterprise.

4 CONCLUSIONS

The development of a knowledge-based economy will require stronger and stronger cooperation between the spheres of education, science and business.

The activity of the university should be aimed at the full use of the scientific potential in cooperation with the industry, but also at improving the quality of education and effective preparation of graduates - future employees and employers. As a result, an increase in the competitiveness of the university and its graduates in the domestic and international labor market is expected.

In the case of BUT and WUST, as well as on the example faculties of these universities educating in the field of *civil engineering*, the process of building the relationship and cooperation with entrepreneurs and business is one of the main elements of the development strategies they implemented.

The benefits of higher education institutions from this type of cooperation include mainly: increasing their recognition among employers and candidates, improving the quality of education (by creating study curricula with participation of employers) and research.

The benefits of students are as follows: better chances for their employment, obtaining payment from the company for their research work, as well as passing internships and building an important network of professional contacts.

The benefits of enterprises have their source in reducing costs and risks, improving the human capital quality, using the university as a source of ideas, promoting the company's image as an attractive and responsible employer, creating a future-oriented, innovative network of contacts, developing new products and services, and helping apprentices.

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