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HOW TO MANAGE COLLABORATION AMONG ENGINEERING SCHOOLS, TECHNICAL UNIVERSITIES AND ENGINEERING EMPLOYERS THROUGH A FIELD EXPERIENCE COURSE TECHNOLOGY

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For many years the engineering community has failed to value practical education. One of the most significant changes might be designing and implementing a field experience course technology based on a practical skills training and competency-based approaches, so the key outcomes of the study are system analysis of engineering schools technical universities and engineering collaboration management, as well as private-state partnership The authors analyze data concerning the changes of school leavers' professional intentions and inclinations, and have studied the percentage of engineering university graduates' employment in accordance with their specialty (major) within one year after getting an education. Three key problems were identified as crucial to engineering education: lack of hands-on experience; underage of long term prospects for the purpose of regional labor markets development strategies; and, a growing rift between career aspiration of beginning engineers and lack of ways to satisfy their anticipation. Upon the obtained results a range of scientific problems and directions can be highlighted which call for further investigation: the extension and thorough research of some theses specified in the article related to creating the system of cooperation and collaboration between engineering schools, employers and job search services.

Keywords: field experience, practical skills, employment, collaboration

INTRODUCTION

Engineering education and training of today, being potentially able to develop efficient collaboration among educators, employers and job search services, does not demonstrate flexibility or willingness to create mechanisms for such collaboration, and sometimes can be marked as hampering beginning engineers' career paths (Tchoshanov *et al.*, 2017). Three key problems were identified as crucial to engineering education.

First of all, a great many of engineering schools do not teach out suitably qualified people with any sufficient hands-on experience. These skill gaps check progress at the outsets of beginning engineers' careers. When embarking on this

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inquiry we asked whether employers in the engineering sector preferred an academic or a vocational profile. The response affirmed that employers want engineers with both theoretical and practical skills. As good engineers need theoretical knowledge and practical skills to enter the profession at any level, engineering education and training must provide both (National Academy of Engineering, 2004).

Secondly, educational services markets tend to promote short-term marketable products without consent of long term prospects for the purpose of regional labor markets development strategies (Rakhimova *et al.*, 2017; Ermolaeva, 2016; Sidelnikova, 2016). Need for engineers will be driven by various factors, including replacement demand due to engineers leaving the labor market and expansion in some sectors, such as nuclear new build and Information and Communications Technology (ICT). National economies today need to: maintain capability in civil engineering, engineering construction, electricity production and distribution, gas, water and sanitation, transportation, process manufacture, nuclear engineering, electronics, food manufacture, fuels, high-value materials, consumer products, IT, software and healthcare services. All depend on engineering knowledge and skills (Duderstadt, 2008).

Thirdly, modern youth labor market goes through a growing rift between career aspiration of beginning engineers and lack of ways to satisfy their anticipation. As soon as beginning engineers do not have enough industrial apprenticeship to satisfy employers with the adequacy of their engineering skills, they become unwanted to fill vacancies. Meanwhile, lack of employability skills and demanding requirements for high wages impede promising work search success among young people (Uljyanova, Morozova & Sopova, 2016; Shaikhelislamov, Shaekhova & Murzalinova, 2016).

Our observation is that more and more businesses are reporting difficulties in recruiting skilled workers they need to occupy jobs. Furthermore, manufacturers expect the problem to escalate with two-thirds of manufacturers predicting difficulties recruiting production staff in the next five years. This concern is shared by all companies, regardless of size or sector.

Thereby, there is a tendency among engineering schools to teach out specialists who do not meet the requirements of the labor market, do not show occupational mobility in the conditions of the changing job and qualification market structure and the passive stand of education in the areas of youth employment (National Science Foundation, 2016).

Engineering schools continue teaching knowingly destined for unemployment engineers, who will have to search for jobs in other territories of the country or even in other countries, whilst their might-be employers will hire adequate specialists in abroad (Nikitin *et al.*, 2016).

The key outcomes of the study are system analysis of a possibility of territorial interaction network among comprehensive schools, colleges and technical

universities, as well as private-state partnership and other modern network instruments of collaboration with the aim to develop measures intended to increase the prestige of engineering profession in society, improve technological open-mindedness and decrease innovation resistance in society, to provide students with certain amount of practical periods conducted at customer's plant as a form of internship and practically-oriented theses research, and to increase the number of engineering schools graduates, able to find job in their major within one year time after graduation (Pokholkov, 2012).

METHODOLOGICAL FRAMEWORK

How might one scientific school vision be fundamental upon the assessment of engineering academic courses, research involvement, and intake for industrial apprenticeship, since we can build upon the significant knowledge base provided by the recent studies conducted by organizations such as National Academies, Science and Economy Committees, engineering professional societies and associations?

It is of vital importance to combine these analyses, conclusions, and recommendations into a ground breaking strategy for the revamp study of engineering education.

Maintaining engineering education studies through efficient approaches and methods implementation

There are many possible approaches to such an effort. The most advantageous are comparative, systematic and analytical research methods.

Since the aim of the research is to find methods and forms to realize an experience course technology based on the collaboration and interaction between education and business, the analysis of observation data concerning the changes of school leavers' professional intentions and inclinations, the results of surveys and interviews conducted among vocational school leavers, graduates and employers on the issue of their satisfaction with vocational training quality are the most important initial stages of this research.

The authors studied the documents and outcomes of educational activity in engineering universities and technical schools in the form of written, statistical, technical and other materials, where the percentage of engineering university graduates' employment in accordance with their specialty (major) within one year after getting an education and percentage of youth employed in the production and service spheres were taken as a target.

Approaches and methods have naturally been a major concern in the field of comparative education. The new perspectives include methods arising from the forces of globalization ... The ever-advancing spread of technology has greatly improved access to materials, and has reduced the disadvantages faced by scholars in locations remote from libraries and other sources of data. At the same time,

technology has spread the influence of the field, making the findings and insights from comparative educators available to a much larger audience through electronic journals, websites and other media, which enhance scholarly exchange (Bray & Adamson, 2014).

RESULTS

Three-Level Model of Social Partnership in Engineering Education to Support a Field Experience Course Technology

To create an innovative model for educating and training engineering and technical personnel, a model that will have a collaboration of social partners acting through engineering schools and engineering employers at its very core, and a model which will support both students 2 theoretical studies and factory training, requires detailed planning and forecasting each possible organizational consequences that might happen as a result of a new model implementation. These managerial tasks are merely executable if only decision-makers rely on and follow methodological principals of proactivity, practical skills training and lifelong learning.

One of the most significant changes might be implementing a field experience course technology through engineering schools, employers and job search services collaboration. This approach will help engineering schools with poor equipped industrial areas to train and educate young people appropriately to fulfill the needs of employers and to help support national economies recovery.

There is some evidence that a three-level model of social partnership in engineering education has proved itself.

- The first level of this model is an educational order. Educational order is that employers, acting as customers, realize their interest at engineering schools starting with recruiting prospective students, influencing their curriculum and training routes up to evaluating course leavers' academic achievements and their skill bases in the frames of the State Educational Standard as members of state qualifying commissions. Within this level, knowledge and skills are basic outcomes to be measured.
- The second level of a social partnership is job placement of beginning engineers. At this level engineering employers evaluate course leavers' academic achievements and their skill bases as well as the degree of their professional competences well-formedness for the purposes of their competitiveness. Here knowledge and skills are not mere outcomes, but means to form competence and professional integrity.
- The third level is the level of course leavers' adaptation and career development of recent graduates. This is the most important level both for course leavers and employers as it promotes successful progression into the labor market. Here the employers measure newcomers' abilities to

meet business requirements along with their personal aspirations satisfaction including their wants for well-paid jobs and high proficiency.

School-industry units' development

The development of technologies and businesses combined with changes that happen within the employment patterns and qualification requirements imposed to engineering and technical personnel at one point, and a countrywide situation when engineering colleges and technical universities have lost the support of their partner work, factories and businesses at another point, result in a burning importance of finding ways to use an opportunity of partnerships between technical universities and engineering employers, including enterprises of all forms of ownership. Partnerships of this kind form the so called school-industry units, which come as partnership-winning groups of enterprises and cooperative organizations, including engineering schools, colleges and technical universities, and aimed at a complementary intercommunion in policy and decision making when training a competitive engineering and technical staff that meets the requirements of innovative industries (Yorke, 1999).

Scholl-industry units are often described as an instrument of social and economic development of a nation and its ability to compete. Many scientists strongly believe that when industries, businesses and engineering schools join their forces within school-industry units, they gain the capability of increasing both national and regional marketability in the world market. This happens due to their ability to add positive impetus and enhance firms and sectors efficiency, as well as to support ground for an innovative, advanced and sustainable development of industries, which will in its turn motivate new businesses to start up.

The core point of this network arrangement is science, and engineering employers become the main consumers of scientific-and-technological achievements of engineering inquiries. They also solve their industrial and business concerns through their participation in students recruiting and curriculum planning; through implementation of field experience courses when training and retraining engineering and technical specialists; and through the assessment of graduates' achievements in accordance with National Education Standards, being members of State Boards for Certification.

Thus, education being a worthwhile community value and advantage, realized for the benefit of people, families, communities and nations, meets peoples2 demands through industry and business development, which results in the growth of social standards of living, and as a whole in a nation's competitive growth in the world market (Bibik & Il2 yaschenko, 2014).

Inspiring young people to consider engineering study and careers

A key element of the model is to inspire young people to consider engineering study and careers and opt for engineering subjects, when they are at the stage of

the curriculum where they choose to study optional subjects alongside with compulsory. It is necessary to show the 14-19 year olds different ways of becoming an engineer as well as different paths to professional engineering, like work-located training, for example advanced apprenticeships (an integrated vocational and work-located learning path); further education college-based vocational education/training (classroom-based learning, possibly including working experience); university-based education, which may include a "sandwich" work placement and/or work experience (general or "academic" path); non-formal and informal learning; and a combination of the above over a working lifetime.

Inspire young people to consider engineering study and careers policy makers along with educators and job search centers specialists can help improve the engineering profession image as a career in the field of innovative engineering and help support priority industries for further development. The major criterion of innovations in engineering education and training management (both planning and realization) is its tendency to focus on methods teaching engineering thinking, and on methods for engineering skills application within each course of study (both academic and vocational). Accordion to this criterion, when educating and training young engineers and technicians an engineering school or a technical university should teach out young professionals able to work efficiently in any field of human activity whether technical or humanitarian, natural science or teacher2 s work. At this when we hear the word *engineer* we imagine people who can pose and solve complex problems, understand structures and can construct and design; people who can master and develop new technologies, organize processes and manage them; for these purposes engineers are able to self-learning (Potaschnik, 2006).

It is only possible to teach out engineering schools graduates worthy to be addressed as *engineers for real*, that is creative and responsible professionals, if we apply an innovative practical skills training approach rather than traditional methods and training technologies.

Education and training of this kind suggests that education and training should go parallel with on-the-job experience within the course a student opted for his study and career. *Docendo discimus* are the words that should become the motto of the innovative approach in engineering education.

Practical skills training approach in engineering education

The world practice knows numerous forms of a practical skills training approach efficient each in its specific area of education and training young engineers. Among the most well-known are special techniques that help communicate professional experience to students by means of their immergence into professional environment through education internship, technological, industry and pre-degree-apprenticeship; through profession-based learning technologies, which are targeted at sufficient professional competences development; through contextual

learning of major and minor subjects; through activity and competence related approach to practical skills training, which is focused on profession and community related competencies formed within the period of education and training at engineering schools and technical universities (Martynov, 2014).

a) Practical skills training approach beneficiaries

Practical skills training approach provides efficiency and attractbility of education and training among various participants of the process, namely:

- among technical universities as it improves the image, increases their investment appeal among engineering employers, and attracts new partners;
- among graduate chairs as it helps arrange field experience courses and employ course leavers, as well as strengthen the ties with professional communities, and provides contracts with industrial enterprises and businesses;
- among faculties as it allows new teaching methods and financial reward;
- among students as it makes provision for well-paid jobs, including administrative work, material interest, contacts with groups of students from other universities.

Engineering schools and technical universities which realize a practical skills training approach gain a competitive advantage in the market for education and employment services in their efforts to recruit talented high school leavers and social partners represented by engineering employers.

The major principle of a practical skills training approach is that it focuses on practical work. This principle lies in academic and vocational programs, their financial and technical support, staff recruiting and their advanced training.

The approach aims at teaching engineering students to manage the technologies of creation, exploitation and sustainable development of innovative products and systems. Course graduates must possess innovative thinking in everything they will have to do.

Practical skills training approach is sufficiently directed to self and group working, managed by a teacher or a trainer, which includes case studies and problems-solving.

b) Problems which can be solved via practical skills training approach

The approach can help solve following tasks:

- reduce and overcome a gap between education and industry;
- eliminate dissociation of subjects and departments;
- gain on-factory experience through field experience courses while at school or university;

- obtain contemporary vocational and personal competencies;
- integrate into the world top universities.

c) Factors that indicate a degree of a practical skills training approach implementation

Among significant factors that indicate a degree of practical skills training approach implementation, following should be mentioned:

1. The number of programs based on practical skills training approach;
2. Availability of specific forms of engineering students2 work placement when they solve practical problems in their fields of education or training in the conditions of real industry or business;
3. Number of partnership agreements between educational organizations and field or regional enterprises;
4. Number of research, innovative and commissioning bodies, including skill-intensive parks, business incubators, etc.;
5. Number of scientific investigations and scientific research results ordered by industries and businesses and carried out with the involvement of students;
6. Number of innovative investment projects supported by national research funds and carried out with the help of students;
7. Patents obtained to get scientific results within investigations carried out with the help of students;
8. Number of course works and degree projects ordered by industries and businesses;
9. Number of employer-sponsored students who take practical skills training courses;
10. Number of employer-sponsored students;
11. Number of graduates who started their own businesses.

Some Urgent Steps to be done to Practical Skills Training

d) Approach implementation

It is necessary to solve some definite problems to reach the aim:

- enlarge the spectrum of program tracks as well the number of practical skills training courses to meet the requirements of engineering employers;
- strengthen collaboration among schools or universities departments and industries or businesses which will help held joint research works, gain research and scientific results, provide employer-sponsored education and training, etc.;

- enhance graduates outcomes in accordance with an employment market demands through field experienced courses, implemented with the help of engineering employers, and via current, mid-term and final assessments;
- recruit employers to Inspiring Young People to Consider Engineering Study and Careers;
- create motivation mechanism to praise students and faculties for their sufficient results in practical skills training approach implementation;
- use the Internet and on-line technologies to create information environment that will enhance collaboration among students and faculties and facilitate practical skills training and young engineers employment;
- cooperate with engineering employers to modernize the best practices of social assistance to young people as a whole and young engineers in particular;
- develop students2 entrepreneurship infrastructure.

If we solve these problems we will contribute to the efficiency of the system of vocational education and create necessary conditions for further realization of a practical skills training approach, which will finally allow increasing engineering schools and technical universities graduates competitiveness in the labor market and will strengthen the position of schools and universities in the educational market (Augusti, 1992).

e) Motivating students to gain professional competences. students2 scientific and research activity

Practical skills training within the programs of educating and training Bachelors, Masters and Specialists as well as within the programs of post-graduate education is being realized through innovative structures (Research and Education Centers, Shared Knowledge Centers, small business enterprises, etc.).

While studying at engineering school or technical universities students become motivated to obtain professional competences they need in their future careers through following activities:

- academic and research work, i.e. scientific literature review, analysis and theoretical justification of problems under review;
- scientific and research work, i.e. theoretical solution, computer modeling, experimental design, elaboration;
- planned scientific and research work, i.e. statement of the problem, theoretical solution, simulation modeling, doing standard application investigations, elaboration, doing nonstandard research works, synthesis problems solving.

Scientific and research work done by engineering students aims at:

- gaining competencies in research work and design and development activities;

- learning how to apply professional knowledge and skills to solve performance-based-assessment tasks;
- development of critical thinking and abilities to synthesize search problems (Kelly, 2006).

f) How to arrange a practical skills training programs implementation

The preliminary stage of a practical skills training programs implementation arrangement includes gathering information from industries – strategic partners of engineering schools and technical universities on professional and personal competencies fit to get place at their factories and to start up work without any long periods of additional training. So, the concern should be with weather a qualification and experience of beginning engineers is fit for the purposes of an enterprise.

Engineering employers have found that the idea of implementing field experience courses within which future engineers are in practice with innovative production and maintenance facilities and equipment helps educate advanced specialists in new engineering fields and post-graduate students in new scientific professions. It also helps beginning engineers understand working in an industrial area and, consequently, enter the workforce effectively.

Progress milestone of a practical skills training programs which follow a competency-based approach lies in some series of arrangements that make the approach work. All the arrangements should be targeted at innovative learning environment creation, where high qualified specialists are taught out to satisfy employers and communities in a whole by the adequacy of their engineering skill base. Among the most urgent arrangements we call:

- construct questionnaires for engineering employers, engineering schools and technical universities graduates, experts in engineering education;
- evaluate questioning results;
- develop methods for forecasting engineering competencies which will fit labor market demand that might arise in future;
- elaborate criteria for level differentiation of competencies (Bachelor, Master, Specialist, Post-graduate student);
- develop classifications relevant to corresponding competencies in each qualification level (Bachelor, Master, Specialist, Post-graduate student);
- create new principles and methods for realizing a credit- module structure of major academic programs and a system of credits;
- design major academic programs for Bachelors, Masters, Specialists and Post-graduate students in Engineering;

- develop teaching materials and training packages in major academic programs for Bachelors, Masters, Specialists and Post-graduate students in Engineering;
- create new retraining and advanced learning programs;
- design multimedia lectures via interactive electronic whiteboards and workbooks for laboratory and scientific research analyses, appropriate for Bachelors, Masters, Specialists and Post-graduate students in Engineering;
- develop digital libraries, which includes digital forms of lectures, student books, recommendations to laboratory experiments and class works, problem books and video lectures for full-time, part-time and distance students.

The engineering community had already started discussions with Governments over how to adapt and develop engineering qualifications in light of the changing workforce and technology, need of a global knowledge economy, which are dramatically changing the nature of engineering practice, demanding for broader skills than simply the mastery of scientific and technological disciplines.

During the past several years numerous studies have suggested the need for new paradigms in engineering practice, research, and education that better address the needs of a 21st- century global, knowledge-driven society.

The most prominent studies in contemporary engineering education are likely to cause very significant changes in engineering education over the next several decades (Morozova *et al.*, 2016).

CONCLUSION

Based on an existing education-science-industry innovation network, which has a continuous collaboration of academic and vocational education in its core, an intensive enrichment of an education and training processes with scientific and practical focal areas aroused by market requirements, businesses, engineering employers and customers is being observed. Such organizational structure of an engineering school or a technical university is being built to attract as more as possible engineering students into scientific, research, design, experimental and innovative work.

Research and innovation departments are the sites where students should take their in-service education programs, technological, industrial and pre-degree practical trainings. It is necessary to equip these departments with up-to-date manufacturing, technological facilities and software support.

Talented and the most motivated students, who approved themselves within practice periods, should be recommended to be employed at research and design departments of enterprises, which provided the field experience course. It is

important if gifted students find their job positions in accordance with their majors being students. Educators and trainers should help design individual education and training routes for these students, the variable part of which will include subjects suggested by employers to be studied more intensively or on an interdisciplinary ground to make students enter the workforce effectively without any long periods of adaptation.

Field experience courses should be provided by industries or businesses on a contractual basis, when collaboration agreements are signed between enterprises and engineering schools or technical universities. These agreements should fix-up the questions of strategic collaboration and partnership, employment, field experience courses realization, information support, scholarships, and other issues that will help teaching out engineers that will change the world.

Students gain valuable career knowledge from work experience and engagement with potential future employers, as highlighted previously. Employer engagement includes day-to-day interaction and involvement in school curricula, provision of work experience opportunities and promotional campaigns aimed at young people and parents. Employer engagement with engineering schools and technical universities is seen as crucial to inspiring young people and enabling a better understanding of what engineering careers can offer.

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