

HOW BEST TO EDUCATE THE FUTURE ENGINEERS

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Abstract. According to the authors, during the process of higher education the model of professional behaviour of the future specialists is formed. It means that the main task of universities is to provide the new specialists with the necessary knowledge and skills which are related to work in changing conditions. That is why more than ever engineering schools are challenged to make deep changes in their programs and structures in order to train the engineer being able to perform successfully in the future and it has been a very hard task everywhere. This article is the result of the research made by a new group of scientists of the Latvia University of Agriculture (LUA) with the goal to study and improve several organizational aspects of the study process and it gives a brief summary of the trends of engineering education and its development at the LUA.

Keywords: competences, Content and Language Integrated Learning, cooperation, study process of engineering, curriculum development.

Introduction

Among the dramatic changes in the labour market it is noticed that now more jobs are part time, more people are self employed, less staff is needed to accomplish work, paid and unpaid overtime work is increasing, as well as global competitiveness, flatter organizational structures, companies downsizing and less job security. Human beings are living now in a changing work environment full of surprises and unpredictable events on a daily basis. The best way to overcome it and to survive is to be prepared for acquisition of knowledge and willingness to develop new skills. It is imperative to be able to manage technological changes, be creative, take calculated risks, manage stress, think conceptually, recognize and respect people's diversity and individual differences. The knowledge required includes the general knowledge of busyness, the understanding of the total organization, at least general knowledge about computers among others. The academic knowledge must provide the basic foundation to get, keep, and progress on a job to achieve the best results. It is necessary more than ever to develop multi skills, among them the communication skills in order to work in teams, to be willing to study constantly in order to learn new technologies rapidly. It leads to life-long education.

Investigation methodology

Research methodology used in this article is scientific analysis and evaluation of a number of information sources and reports, taking into consideration the authors' reflection, experience and observations as well as analysis of the results of participation in research and development activities in connection with the development of the study process of engineering at the LUA.

Results and discussion

To adapt to the new demands of the 21st century labour market many students are analyzing programs before to choose one. The student must choose the right program in terms of the quality and the relevance of the program. One of the aspects analyzed by the students is the institution efforts to place its graduates in jobs after completion of the program. Many programs teach job skills which can be directly applied to a specific occupation. Others provide a broader base of knowledge which can generally be used in many occupations such as communication skills. Graduates from programs that do not have a direct link with a particular job may be forced to seek employment in a range of occupations which may or may not be related to their field of study. Similarly, graduates from programs that do have a direct link with an occupation may have to find employment in unrelated jobs if the demand for workers in that occupation is low [2].

In order to follow the evolution of engineering education and to create possible co-operation models in conditions of our country (employers, educational institutions, local municipalities and schools) the authors have evaluated the kinds and the role of cooperation in engineering studies at the LUA. There are several examples.

Education of building engineers as well as any other professional education is based not only on the Law on Higher Education but also on the standard developed and accepted by a professional organization. In civil construction there are several such professional organizations, but the main of them are the Latvian Building Engineers Union and the Latvian Building Association. The greatest part of Latvian building companies is united in these organizations and they manage the local and the European market as well as the necessary level of professional education. In co-operation with these organizations the study plan for building engineers at the Latvia University of Agriculture is developed and implemented. Co-operation of the departments of the faculty with employers is based on collegiate relations. Professional building engineers are regularly involved in delivery of lectures and seminars, supervision and assessment of internship.

Professional field practice is very important in education of building engineers. In the period of time from 01.05.06 - 31.05.08 within the frame of the European Social Fund at the Department of Architecture and Building two projects were implemented on the improvement and development of the internship in Latvian building enterprises for the students studying in the program of higher professional education in engineering. The aim of the projects was to ensure possibilities and the necessary conditions for implementation of student internship before receiving the diploma in close co-operation of the administration of the building companies and designing organizations, teachers and methodists. It was especially important to prepare the internship supervisors – employees of the co-operation partners – workers of building companies and designing organizations who supplied the students with qualitative possibilities for on-job training and the necessary advisory services. For the internship supervisors the existing professional experience and competence as well as awareness of it are essential. In the seminars organized within the frame of the projects for the internship supervisors the most essential peculiarities that should be considered consulting and educating the students – trainees were stressed. Establishment of personal contacts between the teachers of the Latvia University of Agriculture and the internship supervisors was also promoted. Based on the recommendations of the internship supervisors the stages and the requirements of the internship were adjusted, and they had also an important role in supplementation and revising of the internship program, and methodical instructions for preparation of the internship report.

The experience obtained during the implementation of the mentioned projects shows that the students who have participated in the internship are assessed approvingly by the managers of the co-operation partners – building organizations and designing companies – offering further collaboration and possible work places for the future building engineers. Thus, the internship has a significant role in enhancing the competitiveness of the students. Nevertheless, ensuring of work placement to a large degree depends on the existing demand in the labour market. During the internship the managers of the building organizations and designing companies can personally get acquainted with the student – trainee, his/her professional and social competence, observe the work of the student on the building site organizing work and designing building constructions, assess his/her abilities in communication with colleagues and subordinated workers. The young specialists trained this way who are competent building engineers knowing the up-dated technologies, who are tended to co-operation in different situations and spheres of life, able to act and open to society are especially demanded for in building companies as well as in designing organizations. The deficit of young specialists can be particularly observed in regional towns and rural districts. In implementation of the projects, based on the previous contracts, co-operation partners were involved: the Latvian Association of Building Engineers and the Latvian Association of Builders, SIA „Kalnozols celtniecība”, SIA “a222”; SIA “Zemgales tehnoloģiskais centrs”, SIA ”Skonto būve” and 25 more building companies. The co-operation partners who were involved in the projects gave invaluable investment in achievement of the set aims ensuring development of the internship supervisor competences (participating in educational seminars), the compliance of the internship content to the program (participating in organization and implementation of the internship) ensuring for the students a possibility to implement the aims and tasks of the internship as well as promoting the involvement of the internship supervisors in elaboration of the requirements and development of methodical materials.

An important form of co-operation is the link of the student scientific work (bachelor and master papers) with employers. Most of the themes are actual and related to topical problems in civil construction and overall in the state. Some examples: Characterisation of the element facade Schüco

Skyline and technical-economical comparison to S65 Schüco FW50+; production and application in construction of Keraterm blocks as ecologically clean building products; building construction price estimation problems and comparison of costs; NCC construction; G factor in constructions; comparison of LBN 201-96 "Fire security of buildings" and LBN 201-07 „Fire security of buildings”.

At present energy efficiency is a very important issue in the country. This year at least 8 bachelor papers will be written in relation with the methods of energy audit and certification of buildings. It is planned to develop a special professional master program for acquisition and research of issues of energy efficiency. Co-operation with road building enterprises is also being developed for the needs of which the necessary specialists are trained by means of elective courses at the Faculty of Rural Engineers. All the mentioned measures guarantee a high level of theoretical education for the young building engineers as well as professional readiness for work satisfying the labour market demand.

The co-operation with employers embraces other directions. For example, several enquiries were carried out among the employers of the graduates from the Faculty of Engineering during the last five years with the aim to determine what competences are most necessary for the future engineers to be successful in their professional field. Considering the conditions in our country today it was not a surprise to discover that among the specific professional competences foreign language and cross-cultural communication competences were mentioned. Besides, they were considered to be one of the most important ones by the employers and ranked high in the list of competences.

In order to train the future specialists in compliance with the requirements of the labour market in our country and the world, a necessity arose to change the process of studies in the way that the development of the mentioned competences is ensured in the sessions of the English language. It should be stressed that the students at the Latvia University of Agriculture are not taught the language as such, but professional English or English for special purposes. The terms that students acquire depend on the speciality the students are studying. At the Faculty of Engineering the students are learning the terms related to mechanization, auto transport, animal breeding, milking and milk farming, energetics etc. These terms are not taught separately but in the context of special texts. Also other teaching materials are used as foreign languages are taught with the aim to train the four basic skills – reading, speaking, writing and listening. As the students at the Faculty of Engineering are learning foreign languages only in the first year having two sessions per week, these sessions should be constructed in a way that the students can acquire most of the material that is offered by the teachers and that the competences necessary for engineers in their future professional life can be developed at most. It is not an easy task for the foreign language teachers. Nevertheless, it is possible to apply many different approaches and methods in foreign language teaching to achieve remarkable results.

Already starting from 2003 within the frame of the international, scientific Leonardo da Vinci project CLIL.AXIS (CLIL means Content and Language Integrated Learning) several experiments were started at the Faculty of Engineering to apply the methods that are offered by CLIL. The leading specialists of CLIL application in Europe David Marsh, Bruce Marsland and Kurt Stenberg in their book “Integrating Competences for Working Life” offer eight main methods that can be introduced through the application of CLIL in the process of studies. These methods are: affective learning, authenticity, autonomy or self-directed learning, co-operative learning or peer learning, experiential learning, learning styles, reading strategies and scenarios [7]. These methods are more closely described in the publication of the proceedings of the 6th international scientific conference of the Faculty of Engineering in 2007 [6]. The given methods can be successfully applied in foreign language teaching in co-operation with the teachers of special courses at the Faculty of Engineering.

As the application of the CLIL methods can be varied in different ways depending on what the knowledge of students and their competence level in foreign languages are, the teachers can choose the most appropriate ones for application of them in definite groups of students. There are no homogeneous groups even in full-time studies, but the knowledge of part-time students is often on a considerably lower level. The methods of CLIL allow for individual approach to every group and every student. Applying the methods of CLIL the ways in which the methodologies could be integrated should be considered when teaching through the additional language. This is a key feature of successful CLIL because it is not only curricular integration which you need to consider, but also

how the methodologies you actually use in the learning context will become integrated to meet the different course objectives [7].

Another thing that should be taken into consideration is the motivation of the students as well as the teachers, both – foreign language and special course teachers – to participate in the process of studies applying the methods of CLIL. Introduction of CLIL will have an impact of the roles of the teachers as well as of the students in the process of studies. The roles, relationships and interaction will change. The students will be the final users of the knowledge acquired through learning applying the methods of CLIL, that is why they should be included in discussions about how to organize this kind of studies and what the best ways of their participation could be. In relation to the teachers "...the content and language teachers should make sure that they cooperate enough to have credibility in the eyes of the students. If all teachers, content and language, show that they share an interest in developing students' skills in the professional field then this is a good start. For this to happen, the content teacher should overtly show commitment to language and communication issues and the language teacher commitment to the subject" [7].

In order to motivate the students for application of CLIL in their studies the main point is that they understand the goals of this kind of learning. They should know that it will ensure them future perspectives with respect to employment and career development. They will have a possibility to learn in different ways that ensures more pleasant and interesting acquisition of the material that is taught, they will master the foreign language skills as well as they will acquire deeper knowledge in their special courses at the same time as the application of CLIL methods helps to understand the material more profoundly and comprehensively. Besides, these methods can be successfully used to develop team work competences that are very important for the future specialists in their professional life. The most essential outcomes of the application of the methods of CLIL are: improved motivation to learn both – the foreign language and the special courses as the inter-subject link is ensured in the best possible way, developed level of knowledge in both mentioned courses, experience in application of different methods of work, developed foreign language competences, developed team work competences and feedback for the teachers etc.

Speaking about the teachers, also their competences are improved and developed alongside with the competences of the students as they go through the same process. The teachers and the students are as if in the same boat having the same aims, using the same methods and getting the same results. Cooperation of the language teachers with the special course teachers not only improves the knowledge of the teachers but also establishes good, collegiate and friendly relations among the staff members. And the relations among the teachers and the students become more reliable and friendly what is another prerequisite for motivation to learn and co-operate.

Opinion of the term "engineering" is currently changing. Nowadays the latest findings define engineering as a creation of something new by using science and mathematics. For example, Accreditation Board of Engineering and Technology (ABET) define engineering as a profession connected with studies of mathematics and natural sciences, experience and practice that is applied to develop ways how to economically use the natural resources to facilitate the existence of the mankind. For that reason it is important to define the role of mathematics studies in engineering education and realize the necessary changes in mathematics study programs. It challenges both - engineering education in general and mathematics study curricula in particular as well as approaches used in teaching mathematics as a part of engineering. That is why during the years 2006 - 2008 the Department of Mathematics of the Latvia University of Agriculture introduced the ESF project "Modernization of Mathematics and Physics Studies at LUA". The project included various aspects of the study quality: improvement of educational programs, development of methodological materials, and modernization of material resources and cooperation of participants of the study process.

Improvement of educational programs included evaluation of the size, contents and competences of the current programs. The improvement of the programs was based on two principles: information and communication technologies (ICT) based approach (focus on use of mathematics when using ICT) and development of competences needed for the labour market. The most significant improvement in the basic study programs was practical computer classes that gave students an opportunity to improve the ICT usage. Expanded use of ICT during mathematics studies can be explained by availability to more mathematics software. In order to activate the practical use of mathematics knowledge and

competence in profession, within the project a number of higher level training programs were improved – *System Mathematic Modelling, Use of Mathematic Methods, Mathematic Modelling of Forest Stands*. These subjects mainly have been developed for learners of engineering.

In order to improve cooperation of the participants involved in education programs, program directors of the LUA participated as experts because they are in between all parties that are involved in the study process – students, lecturers and employers – as well as program directors are aware of the needs and objectives of a certain training program. Harmonization of the contents, time and output of training programs of mathematics and other subjects facilitates the quality of the study process. The program managers and the Deans of departments have regular training seminars in order to assess the changes and study the preferable emphasis.

How best to educate the next generation of engineers? Global changes in engineering require a new kind of engineers that is why it is crucially important to realize the necessary qualifications for the future engineers and **transform engineering education to development of engineering skills and abilities**. On the other hand, the development and diffusion of ICT have changed society dramatically, into something which is now sometimes called the information society. ICT makes it possible to collect processes and transmit information much faster and more cheaply than before. In response to the ICT developments, educators and educational institutions are in search for teaching methods, techniques and technologies that make teaching more efficient and effective.

There are some topics for discussion. The researches done by the authors proves that basic principles of didactics could be based on scientific character, system character, relation between theory and practice, deliberateness, unity of concrete and abstract, simplicity of knowledge, soundness of knowledge, combination of individual and collective [3]. For high quality of the engineering educational process it is necessary to implement a set of all these principles, not allowing underestimation of even one of them.

Despite the fact that the size of general engineering studies by the means of contents has not been changed for several years, it tends to decrease by the means of time. Moreover, the problem is that the curriculum has evolved through addition not redesign. It is needed to eliminate something from these curriculums, develop interconnections among units and courses, and link the formal curriculum to an informal curriculum. Social sciences, ethics, psychology, economics, foreign languages etc. should be included in engineering education. The role of these subjects for forming the personality of engineers is obvious. They may assist engineers in solving economical, social and ecological problems in technical projects. From these requirements another question of curricula development follows - whether to include general education in engineering education or not, which is the appropriate extent and proper methods. The methods of education should not be restricted to lectures and examinations only. Active participation, e.g., elaboration of essays, projects, individual students' presentations etc. should also be included in these courses.

The curriculum development is connected with the proportion of compulsory and elective courses. The electives should not be only some supplement to the compulsory study program. Under such circumstances the students seldom choose electives. The disadvantage of a great number of electives is in a greater demand for a number of teachers, lecture-rooms, laboratories etc. Among advantages the competition of different courses and teachers may be included. Unfortunately, students sometimes do not always prefer better courses. They often search for courses that are easier to pass.

In the opinion of the authors, different methods can be applied in engineering education. It is necessary to pass from presentation facts to active teaching methods. It is not possible to limit independent work of students only to creative thinking in lectures, seminars, laboratories etc. Laboratories are an essential part of engineering and technical training programs. Training programs with a high-level equipment requirement are greatly promoted by the funds for vocational training. The laboratory equipment provides efficient support in creating harmony between theory and practice. With the help of practical implementations, students learn the subjects, interpret the data, and develop their evaluating, designing an experiment and practical skills.

The question of the proportion of the so called contact hours in engineering education follows, because a large number of lecture hours may lead to passive education and to development of reproductive abilities of students. The problem of shortening of contact hours and extension of

individual work of students solving problems, preparing projects etc. should be approved. In some cases it is assumed that the best proportion of lectures and exercises is 1:1. In other cases this proportion, e.g., in mathematics is 1:0, when active methods and students' self studies are used.

ICT definitely play a crucial role in developing the teaching/learning processes at all stages and no new teaching/learning environments can be created without ICT. The use of new media in engineering education has to help, support and fulfil its most important objectives. One of important areas of their use is in lectures to make them more illustrative and better understandable. The teacher should keep in mind, that technical means are not only to make them the lecturing easier, but that they are for making easier following and understanding the content of the presented material.

Conclusions

1. There is no formula but it is worth to search for the best way to train the engineers not for the present but for the future. There is not only one answer and the point is that the engineering schools are the ones responsible for the formation of generations of engineers who are among others the main characters responsible for the development of engineering seeking for the betterment of humanity.
2. It is important to decide how to organize the process of educating engineers in order to improve the compliance of the offer of engineering education with the trends of society development. Global changes in engineering education are very fast. The management of this process is hindered by the fact that there is no precedent in Latvia as well as there are no regulations to base on. Therefore, in order to facilitate the development of continuous, co-ordinated and systematic engineering education **research should be carried out** that includes investigation, exchange of experience, co-operation among all parties included in the process of engineering education etc. That is why new groups of scientists at the LUA have been created which are aimed to implement inter-disciplinary research focusing on ICT, languages and mathematics as well as to find out their role in developing the competences necessary for engineers.

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