SOME ASPECTS OF SKILLS AND COMPETENCES IN ENGINEERING EDUCATION

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Abstract. The present article summarises some findings of educators from St. Petersburg and Jelgava in the research in competences and skills necessary for engineers and the ways how to improve the process of studies to develop them applying different new methods. Exchanging of experience among teachers and sharing ideas help a lot to make this process faster and easier; co-operation among teachers promotes also co-operation among students and it, in turn, disseminates information not only at national but also international level. Teachers and students can learn a lot from one another and it allows for omitting of some unnecessary stages in the research processes.

Keywords: competences, skills, engineers, process of studies, development.

Introduction

Studying pedagogical publications and proceedings of scientific conferences it can be seen that there are numerous articles dealing with engineering education. One of the most essential problems in this field is determination of the competences that are necessary to be acquired by the future engineers for them to be able to integrate in the labour market after graduation, to hold the posts they have managed to occupy and to make a career in their professional lives afterwards. As the graduates from the university will be faced with different challenges starting their professional life, they should be equipped with certain key competences that will help them find solutions in different situations in their professional as well as everyday life.

Highly developed competences of graduates are important as they demonstrate the quality of higher education at the same time they ensure competitiveness in the labour market not only for the graduates themselves but also for the country they live and work in. Human resources determine the level of the development of the country, the living standard and competitiveness in the global economic system.

Only knowing exactly what should be taught, what skills should be trained and what competences developed it is possible to organise the process of studies in the way that the set aims are achieved most efficiently.

Materials and methods

In the first stage of the research scientific literature was studied paying attention to the definitions of competences and skills given by researchers of different countries. There can be found very many definitions of these terms as there are many approaches in defining them, so the most appropriate ones had to be selected that could suit in further research in engineering education at the level of higher education.

As it is mentioned above skills and competences reflect the ability to perform work on high professional level. Based on this statement two definitions of competences were chosen to be the most appropriate ones for the present research:

- Competence can be defined as the ability to acquire and use knowledge and skills in action with a sense of responsibility, which should be assessed through performance according to the appropriate criteria (as standards of profession involving occupational requirements) (B. Briede) [1].
- Considering competence as the ideal of upbringing it can be defined as an individual combination of abilities and experience based in the possibilities of getting experience (I. Maslo and I. Tilla) [2].

Professional competency consists of two parts. The first one is personal behaviour. It depends on mentality, psychology and experience of the individual. The second part is created during education. As a result professional possibilities of every person are different.

University education has to create behaviour related to the future professional work. Nevertheless, it affects the personal behaviour, too. This affect is a result of hidden processes. If we wish to estimate the quality of teaching we need to study only the professional behaviour of the individual. It is clear that both have personal scattering. So, the quality of teaching must be described as average values of personal indexes.

Results and discussion

Teaching creates new knowledge which, in turn, brings about the development of generic and content-specific skills for students. Three levels of skills can be identified. The higher level includes skills used by an individual in making connections among different ideas and concepts, introducing new hypotheses, distinguishing among a variety of factors and eliminating those of a random nature. Such higher level skills characterize human creativity in general and therefore they are not content-specific. In other words, these skills can be associated with creative individuals working within content areas as diverse as biology, education, civil engineering, and semiconductor materials research to mention just a few examples.

The second level includes skills associated with professional abilities that are content specific. Such skills are different for different professions. For example, skills and abilities of a civil engineer are quite distinct from those required from a semiconductor materials engineer. Despite the apparent diversity of the second level skills, one can recognize several common features that underlie them. Skills and abilities common to a variety of fields are related to routines dealing, for example, with estimation of errors, interpreting information presented in different but traditional notations, systematizing results of experiments, etc. These routine skills constitute the third level in the classification used in this paper. In what follows, skills that belong to the third level will be referred to as engineering skills.

Several skills, regardless of their level, develop in the course of study of a particular subject matter – mathematics, physics, chemistry, and so on. Yet other skills, such as a proficiency in using an index, handbook, thesaurus, and calculator have essentially an interdisciplinary nature. Such skills emerge as a part of a student's repertoire through his or her active participation in a master/apprentice type of a learning environment. Often in a lab setting, the instructor-student relationship moves quickly from the expert/novice plane to the master/apprentice plane and that type of educational dynamics obscures actual processes responsible for the development of the above interdisciplinary skills. In other words, one can identify skills that develop through hidden educational processes.

To check the quality of teaching it is necessary to measure several indexes. The best way is measuring of the so called mastering index. These results may be compared with practical requirements. The requirements are very different. To find them is the main goal of optimisation of education. The compliance between skills and abilities, and the requirements have to be checked twice. The first period of checking must be organised after the first and second years of studies. The second must be organised after graduation.

There are different ways to determine the requirements. A standard approach to such a task is organisation of an opinion poll among different groups of experts. A major problem associated with the polling approach is to develop an accurate list of multiple choice questions. An alternative approach is not to use multiple choice questions as a polling tool but rather to create a list of questions through the polling process. To this end, the Delphi method commonly used in the area of scientific prediction was administered. The authors asked a group of experts of the university faculty, industrial researchers with advanced degrees, and practicing engineers to create a full list of skills necessary for an engineering background. As a result, each expert came up with his or her own list of responses presented in a loose format. According to the Delphi method, all responses were analyzed and the skills common to all the lists were identified and recorded in the final list. Nevertheless, different methods to determine the requirements are used. It can be study of professional standards, study of professional mistakes, the Internet search and so on.

The list of the requirements has changed with time. These changes are affected by new teaching ideas and by environmental factors. For instance, globalisation processes created more serious requirements in the field of foreign languages. Multicultural situation affected the tolerance requirements. Informatics created new methods of work and teaching.

Different intercultural contacts, stresses and conflicts take serious place in the modern world. That is why the educational technologies of persons which must live in this complex environment is one of the main problems of schools and universities. We have to cultivate in our students high liability and tolerance. The students must have a good will for understanding persons of different confessions, races, nations, ages, sex and professions. How can we produce such behaviours in the student's nature? The most part of stresses and conflicts is created as a result of discrepancies in the surrounding environment. There are two widely spread mistakes we meet in the discussion of intercultural problems. The first one is connected with the assumption that it is possible to destroy all discrepancies in the world and to build a non-conflict situation on this base. The second one is the assumption that it is necessary to study the leading conflicts only. The national and language contradictions are studied in the first order in this case. Yet, the most part of other problems is usually omitted. Still, these omitted sources of conflicts can create serious stresses in real life. It is impossible to create full homogeneity in external environment. Struggle between the tendency to homogenisation and the opposite tendency to stratification takes place continuously in every part of our world. If we have to produce homogeneity on one level of the human society the new inhomogeneity with its own contradictions immediately is created in another part. That means we are living in a highly diverse world. This situation is not accidental. The diversities are the main characteristics of nature and as a result the diversities occur in our minds, ideas and notions as reflections of nature's properties. So we have to study the life in a very complex and diverse environment. It is possible to say: the multicultural social life is an immanent part of our world. Before we may discuss the ways of educational strategies in our universities and schools we have to take in account some main properties of diversities.

We also have to take into account that the 21st century is the time which is connected with global revolution in the social life. This revolution is called “The third wave”. Its content is connected with introducing of new up-dated technologies in industry. Its content is also connected with creating of new fields of human interests. There are two main directions of the changes in the surrounding world caused by the third wave revolution in some last decades. The first of them is globalization of all human contacts. The second one is connected with growing of information processes and technologies. We can see power shift in politics as a result of these changes affecting the social life. This shift is caused by destroying of old patterns of social life. New patterns are created in it. It explains why multicultural structure of the world became very unstable and complex lately. There are many stresses and conflicts created between the new and old patterns of society. That explains why the study of different diversities must be the starting point in the field of producing educational strategies. It is impossible to eliminate conflict situations as in the educational period as well as in the period of post educational life there will be challenges that can create conflicts [3].

Let us start from the description of global properties of diversities. If we look around we can see that there are not two fully equal subjects in the world. Every tree has its own structure of branches, leaves, roots. Two cars are different to some extent. It is not difficult to continue this enumeration. At the same time different subjects may be treated as similar if we look at them from the other point or from the other level of study. So we can say that all surrounding world consists of diversities, which are in some order and have many similarities on large scales. Reflection of these diversities in our mind causes diversities in our logical structures, too. In spite of different behaviours there are some general laws which describe the properties of diversities. These laws were in study by Ancient Greeks and Middle Ages scientists. Yet, only in the recent years some conclusions and general alignments were found. It is very convenient to describe these laws in a mathematical-like form of theorems. These theorems are correct in all possible fields of human knowledge. So they are correct in the education area, too. It is also necessary to take in account the multicultural environment as a typical case of diversities in the social area. That is why it is interesting to discuss how the main theorems of the general theory of diversities can explain some educational problems of multicultural world [4].

There are some conclusions in the general theory of diversities, which are the base for the study of education processes in the multicultural world. The first one is that diversities are an inalienable part of the surrounding world. If we meet oneself with a large part of nature which is homogeneous we can be sure that in a very short time the opposite process of stratification will begin and a new diversity will be created. There are different parts or subjects in each diversity. Some of them are highly developed, but at the same time the other part of subjects is only weakly developed. All subjects of any diversity are gathered in clusters and patterns. The number of subjects in each cluster of the same level of diversity changes very strongly. The most advanced clusters usually consist of few subjects only. Yet, these subjects are frequently the leading ones. Interface between two clusters is the zone of maximal stress, which creates new subjects of diversity. The new diversities are also born in the contact zone of different clusters. Yet, at the same time the contact zone is the field of maximal exiting and stresses. The structure of each diversity has not only typical hierarchic structure consisting of some levels. There are some connections in the plane part of each level of diversities. So we can say the diversities have the so-called net structure. The diversities show themselves on each vertical level of the global system organisation. We can usually observe that there is the main level of the net structure which produces stress. If we suppress this stress new stresses are created on the lower level. These stresses frequently may be more stronger than the starting one. That is why the searching of the optimal level of stresses and conflicts is a serious part of each educational strategy [5].

We can draw some conclusions from these enumerated behaviours of the main properties of diversities. The first and may be the most significant conclusion is that there is no sense to try to avoid different groups of individual interests or behaviours in the process of education. If we find any conditions for suppressing any inhomogeneity in our environment a new one will be created instead. If we suppress several sources of conflicts new sources will be produced in a relatively short time. So, all educated persons will have to live in multi-behaviour structures. Multicultural situation will exist in every group of students and the teaching staff, too. Thus, the main goal of education is not to make attempts to suppress diversities. In the opposite – every teacher should understand that it is necessary to tune his or her students to live, educate and work in very diverse and complex environment. We have to teach students to adapt to multicultural world. That means that every person after graduation must be tolerant enough to different behaviours of peers, understand the necessity of diversification of customs, confessions, knowledge level, educational background and possible different properties of other persons. The teachers must not only understand this situation. They must know how to move the possible contradictions to the optimal level. They also have to create such individual students' skills which can permit to transform all frictions and stresses between multicultural classes of people we meet in our life in a soft form. It is meant a soft form of stresses between persons that is related to peaceful and benevolent competition between different individuals. On the opposite, the hard form of stresses is related to quarrels, struggle and other properties of intolerance.

It is necessary to have some practical programs to develop these ideas. These programs, first of all, have to be connected with training of teachers. This training must be accomplished with social testing of students and appropriate checking procedures. We also need to find some special organisation and theoretical forms of the educational process. Speaking about students' education we must start from a suggestion that it is not effective and non-realistic to give special lectures about tolerance, different habits of nations, races and so on. Such lectures are certainly useful. Nevertheless, they cannot solve the main problem of tolerant education. The students' tolerance may be cultivated as a result of everyday hidden work of all teaching staff only. There are some methods of such education, of course. Let us discuss the simplest example. There are many foreign students, which are educated in the most part of European universities on Erasmus and other exchange programs. There are some problems, which usually these students face in their everyday life. These problems include language barriers, differences in previous school teaching, culture shock and other evident factors. Foreign students are usually dissolved in the host stuff. Yet, in some cases isolated groups of such students are created. That is why searching of optimal strategy of mixing host and foreign students is necessary. It is also necessary to find additional forms of contacts between host and foreign students in the period of their free time. Correct organisation of such contacts is one of the effective ways of overcoming intercultural barriers and creating more tolerant line of students' conduct. It benefits both – foreign students and local ones. For all of them it is possible to learn more about their specific cultures and

mentality what on its turn helps establish better contacts and get on together easier. The goal of educational strategy is not to make attempts to avoid differences of contradictions but to create normal spirit of them. The students have to be explained that contradictions are a constant part of our common life. They must understand that different human behaviours, confessional differences, race and national habits are the base of diversity in the society. That is why the students have to check their strategy in everyday contacts as in the private, so in the communal life.

It is worth repeating that all these education strategies have to be implemented in the hidden processes. The hidden processes are responsible for cultivation of social behaviours of individuals. There are some hints which permit to examine the hidden processes. These hints can be different for different situations and different teaching subjects. It is possible, for instance, to encourage students to describe their impressions from contacts with students of different countries about their sex, age and confession. At the sessions in foreign languages the students are asked to express their opinion in the foreign language taught. It improves their foreign language speaking skills at the same time. It is also well known that the educational process is depended on external information which comes to the students from TV programs, books and personal contacts. So, continuous study of students' interests is an important part of education strategies that helps the teachers act accordingly in different situations to improve the behaviour of the students.

There are some subjects in the universities which can help the students understand the situation in different countries and other parts of the society. Ecological training exercises involve description of the actual situation in different countries in the teaching process. For example, if the students discuss with their teachers the ecological situation in the Baltic Sea region they must understand that some countries: Russia, Latvia, Finland, Sweden and some others are closely related together. Each unexpected pollution in Russia affects the nature in neighbouring countries. That is why at practical ecological training the student can receive many additional information about the nature, customs, laws and different plants in the countries of the whole Baltic district. If the lectures appropriately include such examples they direct the students' attention to the surrounding people and create some tolerant habits as a result. At the period of ecological studies the students are taught to understand the contributions and needs which different human communities and countries have, and so on. Such studies are useful for cultivating students' understanding of intercultural interests.

Speaking about teaching foreign languages, this subject includes great possibilities not only for supplying students with new vocabulary and pronunciation skills, but also with wide information about different countries, cultures, habits of people and traditions. Also such knowledge is needed for specialists today to be able to cope with difficulties that can arise in their professional life through contacts with colleagues from other countries. Courses in professional foreign languages help to overcome misunderstandings and discrepancies of such kind as at these sessions not only the lexicon is acquired but the students are introduced also to the ways how definite matters are dealt with and what ideas are used in other countries [6, 7].

Inter-subjects links can be implemented in many different ways using different methods of teaching/learning. According to the opinion of the authors of the article the most efficient method is using content and language integrated approach at the sessions of foreign languages as well as at the sessions of special subjects. This approach has already proved to be successful as it includes many possibilities to apply various methods and styles in the process of teaching that are not only useful but also interesting both for students and teachers. Surely, some preparation is necessary for the teachers to be able to operate with these methods. The teachers should also have some knowledge in both of the subjects that are taught using this approach. Also students should be trained accordingly to be able to follow the instructions, understand the material to be acquired and be ready for active participation in the process. Both parties should be ready for the change of roles as teachers become advisers instead of being instructors and the students have to become quite autonomous, creative and independent. These factors will ensure positive results, good outcomes and benefit for students and teachers if the content and language integrated learning methods are applied correctly [7, 8].

If inters-subjects links are used in the process of studies, it helps the teachers and students teach/learn more in a shorter period of time simultaneously training the students’ skills in both subjects. And it ensures efficient feedback that facilitates further improvements in the teaching/learning process.

Conclusions

1. Success in professional performance can be achieved through training not only specific professional skills but also through development of other competences that ensure effective participation of the specialists in different processes encountered in their sphere of activities.
2. In the present article three levels of skills are identified; they are non-content specific, content specific and engineering skills. Professional competency is influenced by behaviour, training and education. The study process at the university should be organized in a way that professional competences are developed in the most efficient way.
3. To train the necessary skills most efficiently it is necessary to define the requirements that the specialists will have to meet at their work. It can be done through enquiries, interviews, observations etc. These requirements can be very different and changing continuously, to find them is the main goal of optimisation of education. We should take into account the diversities around us that are existing in today's multicultural world to plan the educational strategies correctly.
4. At the sessions of foreign languages students can improve not only their foreign language skills and cross-cultural competences but these sessions supply the students with versatile information that promotes better integration in the labour market which is very multi-national in today's world. The more the young specialists will know about different cultures, habits and mentalities, the easier it will be for them to be successful in communication with people around them. Knowing foreign languages helps to overcome the language barrier and to overcome or even eliminate cultural shocks.
5. Inter-subjects links can help a lot in the improvement of the process of studies that is centred to training of engineering skills and mastering of the competences necessary for the future engineers in their professional career. It is beneficial for both – the students as well as the teachers.

References

1. Briede B. Competence Research Aspects, Kinds and Components. Journal of Science Education, vol. 7, 2006, p. 21.
2. Maslo I., Tilla I. Kompetence kā audzināšanas ideāls un analītiskā kategorija (Competence as an educational ideal and analytical grade). Skolotājs, No.3. 2005, pp. 5-7.
3. Romanenko V., Nikitina G. Changing engineering standards at the edge of the new century, in S. Linblom-Yalaenne (Ed.). Abstracts of the International Conference of Innovations in Higher Education, Helsinki. Helsinki University Press, 2000, p. 165.
4. Никитина Г.В., Романенко В.Н. Формирование исследовательских умений в процессе профессионального обучения (Development of Creative Abilities in Vocational Education). СПб: Изд. СПбГУ, 1992. 168 p. (In Russian).
5. Романенко В.Н. Основные представления теории многообразий (Main Statements of the Diversities Theory). СПб: Изд. СПбГАСУ, 1997. 76 p.
6. Malinovska L. Development of Foreign Language and Communication Competences at the Latvia University of Agriculture. Proceedings of the 3rd International Scientific Conference "Trends in Agricultural Engineering 2007". Prague: Czech University of Life Sciences Prague, 2007, pp. 280-284.
7. Malinovska L., Zeidmane A., Mežote A. Content and Language Learning at the Latvia University of Agriculture. Proceedings of the 3rd International Conference "Trends in Agricultural Engineering 2007". Prague: Czech University of Life Sciences Prague, 2007, pp. 285-289.
8. Maļinovka L., Berjoza D. Necessity for Introduction of the Method of Co – operative Teaching at the Faculty of Engineering. Proceedings of the International Scientific Conference "Rural Environment. Education. Personality". Jelgava, LLU, 2003, pp. 39-44.