Interdisciplinary Approach in Engineering Education

doi:10.3991/ijep.v1i1.1604

A. Zeidmane, S.Cernajeva

Latvia University of Agriculture, Jelgava, Latvia

Abstract—The analysis of the scientific literature available on the types of general competences and their classification caused the authors to conclude that it is necessary to implement interdisciplinary approach in engineering education to develop competences necessary for engineers to make them competitive in the labour market. The attention should be paid to a professional foreign language, computer literacy and educational psychology recommendations. To improve professional foreign language skills, CLIL (Content and Language Integrated Learning) method should be integrated in the study process of engineering education. In order to develop information literacy competence, it is important to create a single e-study environment. The academic staff, developing study subjects for engineering programmes, should focus on the study content and study methods. As regards the content, the compromise should be sought between fundamental acquisition of the knowledge of the subject matter, the know-how of the application of this knowledge as well as the use of brand new software in the calculations. The paper presents the examples of the application of the interdisciplinary approach in the universities, where the authors of the paper are affiliated: the LUA (Latvia University of Agriculture) and the RTU (Riga Technical University), respectively.

Index Terms—interdisciplinary approach, engineering education, CLIL, information literacy

I. INTRODUCTION

Engineering education has to fulfill many tasks given by the modern trends in the development of society. Different studies define new goals of engineering education, and technical universities have to fulfill these aims. However, there are several factors that characterize the integrity of the higher education. One of them is the unity of objectives of graduates. After the completion of undergraduate studies, young specialists have to solve the same problems: find a job, adapt in a new environment, take the first steps in their carrier, change work or even profession in case of a failure etc. That is why the system of higher education has to be aware of the competences necessary for graduates that will make young specialist competitive in the labour market.

The situation in the labour market is dynamic: new products are launched, production management system, equipment, technological processes etc. change persistently. Therefore the system of higher education cannot provide an individual with the knowledge necessary during the whole professional life. Universal and sustainable knowledge and skills are significant both for university and for production that will be useful in diverse forms of professional activities in the long-term period.

Problem of Research

The problem of the research is to study general competences of a young specialist necessary for the sustainable carrier as well as to examine the disciplines to be integrated in the engineering education to develop the competences implementing interdisciplinary approach. The methods applied in the research are the study of the scientific literature, student survey and description of the personal experience of the researchers.

II. MATERIALS AND METHODS

International standardization organization (ISO) defines quality as units of characteristic of objects (product, service, action, organization) which designate the ability to correspond the determined and predictable requirements.

Many definitions of competences exist in the scientific literature. Before starting to discuss these definitions it would be useful to consider the multiform **aspects of competences**. One of the most important of these aspects is the **relation to the development of the personality**. It underlines that learning through doing is an essential feature of competence. Learning skills promote activity and it, in turn, indicate that the society is democratic. Another is the **global aspect**: sustainability, postmodern society, democracy, globalization, environment protection, quality of life, human ecology, life-long learning etc. Sustainability is the basic principle of the European Union and it is characterized more detailed in the Declaration on Guiding Principles for Sustainable Development. The main idea of this document is continuous improvement of the quality of life for the present generation as well as for the future generations ensuring the basic rights and freedom for all the nations of the world. The term "competence" includes multi-form semantic meaning. It is developed from the German word "kompetenz". One of the meanings is a wide range of knowledge and understanding in a definite sphere or question. In Latin the word is "compete" that means to be useful and adequate [1]. Today competence is defined also as a combination of knowledge, skills and experience that manifests itself in activities [2]. Competence is a processual and integrating concept including the cognitive, psychical and social aspects of human activities. Competence is also a combination of the qualities of a person manifesting itself in actual activities the person is performing.

According to scientific literature competences are divided into different kinds. Tuning Educational Structure in Europe distinguishes between instrumental, interpersonal and systemic competences (Fig. 1).

Instrumental competences are further subdivided into cognitive methodological, technological and linguistic

competences. Interpersonal competences are subdivided into social, interactional and co-operational competences. Systems competences are abilities and skills in relation to the system and they are understanding and combination of senses and knowledge.

The authors Malinovska L., Zeidmane A., Abele J. [3] have developed a table to classify the kinds of competences based on the analysis of scientific literature (Fig. 2).

Keller and Novak describe the competences of methods. They emphasize that competence of thinking means logical, analytical systems thinking and creative, original flexible thinking. Working competences comprise the ability to withstand additional load, ability to concentrate and readiness to make effort. According to the UNESCO and EU documents political and social competences are to take responsibility, to accept team decisions and to settle conflicts. Readiness for life in multicultural society means to recognize traditions and habits of other nations; languages and religion.

Kinds of competences can be classified also as follows (Fig. 3): professional competences that include professional knowledge, professional skills and reflection; social competences including self-competence that means skills to perform constructively, adequate self-assessment of one's own activities and oneself and to draw conclusions for further activities. Social competences include also co-operation and communication competences.

Social competence is a component of civil maturity that is characterised by the skill to analyse, take decisions and act in compliance with definite conditions in social situations and business or functional situations [4]

Habermas has stressed the role of **language** in communicative activities. Language is a means for the most fundamental form of social activities. Habermas gives a definition of communicative activity: "… it forms social interrelation in which the plans of different participants of the activity are co-ordinated by help of exchange of communication activities, i.e., by means of language to reach mutual understanding". Habermas distinguishes between activities that are centered to success and understanding and social, non-social contexts of activities. Activities centered to success can be measured by rational norms. Activities centered to understanding are carried out by means of communication. It materialises in mutual and co-operational success resulting in understanding between the participants of communication.

According to Briance Mascarenhas, Alok Baveja and Mamnoon Janual [5] there are three types of core competences: superior technological know-how, reliable processes and chosen external relationships. These are the competences needed for every multinational company to be successful. It is possible to relate the mentioned competences to the process of education.

External relationships are of special importance as they help strengthen and extend traditional competences responding to the demands of globalisation, quality and changes. Coyne, Hall and Clifford [6] proposed that "a core competence is a combination of complementary skills and knowledge bases embedded in a group or team that results in the ability to execute one or more critical processes to a world class standard". The skills and knowledge should be complementary and taken together they should make it possible to provide a superior product.
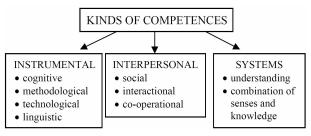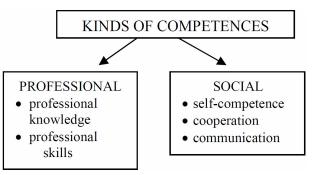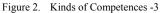

Figure 1.   Kinds of Competences according to Tuning Educational Structure in Europe (2005)
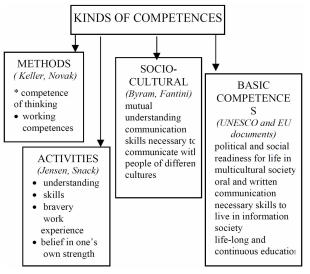

Figure 2.   Kinds of Competences -3

Figure 3.   Kinds of Competences-2

One of the prerequisites for successful integration of the students in international studies is a developed competence in foreign languages.

Each student has to acquire a definite amount of information; the general information that refers to anyone and the knowledge and skills that are specific for the selected profession, i.e., the student has to discover the features of the selected profession and through the process of interpretation add them to his/her personal features. Two sciences among others deal with the acquisition, processing and storage of information – they are informatics and educational psychology that have been experiencing a rapid growth.

The increasing expansion of Information Technologies worldwide creates a new social relationship – the information society. Therefore the necessity of the search and use of information has emerged. The concept of literacy has expanded and acquired a new name – information literacy.

The objective of the education system is the development of information skills.

The term *information literacy* has been defined variously by researchers. For example, researchers in Latvia understand it as the ability of grasping the necessity of new information, an awareness of when and what information is necessary in order to solve a problem, what skill is necessary to search, understand and arrange information, to select the necessary and suitable information from the huge bulk of created and stored information. It is a skill to use this information, share it and produce new information. Another approach suggests that information literacy includes skills that are necessary for the new carrier, citizenship and long-life learning [7]. An individual, who is information literate, is aware of the necessity of information, he/she has the ability to obtain information, use it effectively as well as estimate the result according to the requirements of the task and the relevant knowledge growth [8].

Computer and information competence of students of technical disciplines is a component of information literacy (Fig. 4)

According to the investigations of American librarian association possessing **computer competence** means:

a) knowledge of basic concepts of information science and computer facilities;

b) knowledge of equipment principles and functional possibilities of computing technique;

c) knowledge of modern operation systems, program shells, instrument systems and program means of general purpose;

d) knowledge of modern specialized computer programs and complexes, automating professional activity; possessing some of them;

e) knowledge of training program languages and skill to use them practically;

f) skill to use functional possibilities of computer facilities while preparation, organizing and providing professional activity, as well as renewing one's professional knowledge.

But information competence means:

a) understanding necessity of actual and significant information;

b) skill to find the information sources, using the most effective search strategy;

c) skill to estimate information critically and competently, to differ facts from opinions;

d) skill to estimate the found information creatively;

e) skill to use the received habits on information search at personal purposes and in professional activity;

f) understanding information meaning in the development of democratic society;

g) knowledge and following ethical standards in the sphere of information technologies;

h) skill to cooperate in search and use of information, skill to share the results of one's activity

The study of information literacy suggests various aspects of information culture [9]:

a) cognitive (skills and ideas about new information image of the world at hypotheses and theories);
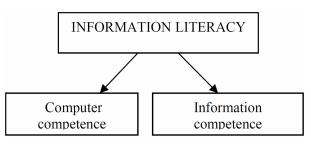

Figure 4.   Component of information literacy

b) operational and contextual (practical skills and habits, connected with the receiving, storing, transmitting and processing information);

c) communicative (principles and rules of person' behavior in information and communicative systems);

d) valuable and reflexive (vital aims, estimations and attitude to the world).

The analysis of the theoretical research permits to conclude that in order to provide engineers with the necessary competences that would enhance their competitiveness in the labour market, interdisciplinary approach should be implemented in the engineering education focusing on professional foreign languages, information literacy, educational psychology recommendations; teaching engineering disciplines could be viewed as having interdisciplinary features.

III.   RESULTS AND DISCUSSION

As it was mentioned before, one of the prerequisites for successful integration of the engineering students in international studies is a developed competence in foreign languages.

Recently a Leonardo da Vinci project called "CLIL.AXIS" was implemented with the aim to improve the language skills of the students. The author of the article participated in this project. CLIL is the acronym for Content and Language Integrated Learning. "It is an educational approach in which languages and skills of communication are given a prominent role within a curriculum. It is often carried out by professionals who teach on courses other than foreign languages" [10]. Another definition given by the same authors:"CLIL is a multi-faceted approach which is implemented to reach specific outcomes which enhances the learning of field-specific education alongside".

It does not mean learning languages but acquiring the contents of the specialty applying the competences of foreign languages. Sometimes our students do not realize the need for these competences as they have negative experience of foreign language acquisition from their background education. The task of the teachers in this case is to promote success in the performance of the students by appraisal of their achievements in this field. The teachers should try to notice and mention any progress of every student in the process of studies. That will stimulate the students, give them higher self-assessment and motivate them to learn more and better. CLIL is not a new method. Nevertheless, the needs for introduction of CLIL today are new; they are determined by the globalization and integration processes in the world. One of these needs in the process of studies at higher education institutions is determined by the exchange programs of students and teach-

ers that are organized within the European Union and all over the world. To be able to participate – to learn or to teach – in a foreign country both of them need to master their foreign language competences.

Acquisition of the CLIL competences helps the graduates be more self-confident; they play an active role in finding a good job after graduation and promote the future specialists in making a career.

At the Latvia University of Agriculture the experiments of team-work with application of CLIL elements have been carried out and they have been quite satisfactory [11]. The first experiments were carried out at the Faculty of Engineering of the Latvia University of Agriculture with the teacher of foreign languages and the teacher of the specialty of auto transport working in a team. The students in the first year of studies were taught special terms in this field in English. In the second year in the laboratory sessions they were given the technological descriptions in the English language. The students had to understand the task and perform the operations accordingly in compliance with the given task. For instance, the students are asked to carry out a similar task to what they can face in the practice after graduation from the university related to technical service of automobiles: tightening of cylinder head bolts. The task is not difficult if the student knows the special terms in English and the general principles of the technology. This kind of team-teaching ensures also good feedback for both teachers and for the students themselves. It is possible to see what the students have missed in foreign language learning as well as in special subject studies. Team-teaching ensures "intersubject" links that is also a very important part in the process of studies.

Another example of CLIL is forming additional elective courses in foreign languages that are connected with engineering sciences. The author of the article designed a new elective course "Applied and Interesting Physics" that was taught in the English language, or at least a part of it was in English [12]. The number of foreign language sessions that are planned in the curriculum is unfortunately insufficient for acquisition of all the necessary terms in the chosen specialty and for understanding the material that is delivered in a foreign language. We consider that introduction of CLIL at the Latvia University of Agriculture could be a solution for this problem. The survey of the students in the necessity of introduction of CLIL at the Latvia University of Agriculture showed that all the students (100%) supported this idea. 86.4% were also ready to participate in CLIL studies, 13.6% supported the idea but they themselves were not ready to participate (Fig. 5).

When asked if the students are ready to study some courses at the Latvia University of Agriculture together with foreign students in a foreign language, 64.4% of the respondents gave an affirmative answer, but 35.6% responded that they were not ready; besides, 90% of them explained that the reason for this is their insufficient knowledge of foreign languages. Only 10% of the respondents did not consider that it was necessary to have such studies (Fig. 6).

As regards the development computer literacy competence, an attention should be paid to the integration of ITC in the engineering education. As it was mentioned before, computer competence and information competence of students of technical disciplines is a component of information literacy. Development of computer competence
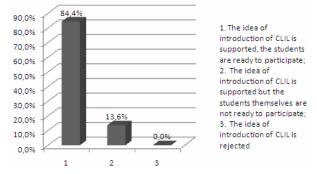

Figure 5. The results of student enquiry in the introduction of CLIL at the Latvia University of Agriculture

1. The idea of introduction of CLIL is supported, the students are ready to participate;
2. The idea of introduction of CLIL is supported but the students themselves are not ready to participate;
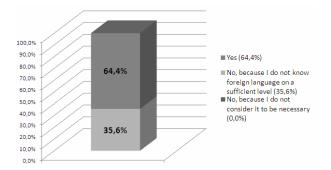3. The idea of introduction of CLIL is rejected

Figure 6. The results of the student survey in the possibility to study some courses at the Latvia University of Agriculture together with foreign students in a foreign language

includes focusing on new knowledge computer facilities as well as acquisition of knowledge of modern specialized computer programs. At the same time information competence should not be neglected, where an important skill is to estimate information critically and competently. It means that a new specialist should have fundamental basic knowledge and developed cognitive abilities. Therefore the focus should be on the content and the teaching methods when designing new engineering subjects.

As concerns the content, a compromise should be found between the acquisition of the fundamental knowledge, acquisition of know-how application of knowledge as well as the use of IT software in the calculations. Many colleges concentrate mainly on the education of "users", because they think that the most important thing is to teach students to perform the necessary calculations. What is the main objective of the university: should students be taught "how to do it?" (the authors think it is the task of secondary technical schools) or students should be taught "why should it be done?". The latter requires serious theoretical studies of the respective subjects which require mathematical demonstrations that develop cognitive abilities and provide with understanding of interconnections. Likewise, we cannot ignore the achievements of IT and neglect the skills of software application with the help of which rapid calculations are possible.

As a case in point, the integration of IT in the study process of Mathematics at the Latvia University of Agriculture could be mentioned, where one of the authors of the paper is affiliated. The acquisition of software Math-Cad is integrated in the study process accounting for 0.5 of contact lessons per week.

Professor of MathCad in cooperation with the professor of the practical work hand out homework to students

about corresponding topic which they must solve on the paper, showing the process of solving step by step, afterwards in the practical classes students using MathCad programme check solutions themselves.

The analysis of the students' success and the students survey at the LUA shows that students prefer the introduction of MathCAd in the study subject of Mathematics instead of learning MathCAd as a separate subject supplied by mathematical examples. Students enjoy comparing the results of their individual tasks with the results obtained via MathCAd, that, in turn, increase the motivation to solve more mathematic problems, since students are interested in solving several variants. The final tests complete the study period of individual tasks and MathCAd problems thus the final tests show the improved scores.

As regards teaching methods, it is necessary to mention a new phenomenon – the exchange of information on personal achievements which should have far-reaching influence on the teaching process. Accordingly, the material of many traditional subjects will be adjusted to the group work as the form of research. More precisely, an academic student group will be divided into groups, each of them working on a engineering problem set by the lecturer; when the result is achieved, the groups exchange the scientific information. Due to such **organization of the study process,** firstly, the dual nature of personal-social science is exposed; secondly, engineering subjects, alongside with other disciplines, are involved in the development of a range of important competences:

a) personal and social responsibility,
b) ability to plan,
c) communication,
d) language skills,
e) skill to cooperate and others.

In order to develop ITC competences, it is advisable to create a single e-learning environment at the university with two-fold aims: firstly, to provide students with the information of study organization, and secondly and most importantly, to assist in the learning process.

The Riga Technical University (RTU), can serve as a positive example, where commencing with 2007/2008 academic year there has been transition to united e-learning system using the RTU website ORTUS which is based on e-learning program MOODLE (Modular Object-Oriented Dynamic Learning Environment). The main task of ORTUS [13], website is to provide support for the scientific and administrative processes by facilitating effective communication. The establishment of ORTUS website is advantageous to the students, the administration and it improves the inner communication of the university by providing the administration with the necessary feedback from the students. ORTUS at the moment is the most modern, widest and the most multifunctional higher educational establishment website in Latvia. At the moment several subsystems are integrated there which provide with united access to RTU e-services, giving advantages to the students, the lecturers and the administration by improving the university's inner communication as well as providing the administration with the opportunity to receive feedback from the students. The lecturer of each subject provides his/her students with various ways of self-preparation for tests and examinations. Home tasks, the solutions of tasks, lectures and tests are posted on the

website, and by comparing the completed tasks the students can assess their level of readiness in each particular subject and its final examinations (Fig. 7).

In the usage of the web site for the studies of engineering subjects it is essential to pay attention to the didactical aspects of the studies. Very important is the creation of the notes of the lectures and the suitable self-control tests. In the creation of the tasks, examples as well as the home tasks it is essential to set the difficulty level for each task and accordingly create the tasks by slowly increasing the difficulty level. It is also very important to create suitable marking scale system where would be included the motivation to attend the lectures and students could independently improve the knowledge of subjects by using the given e-course. Thus it is of a paramount importance to create suitable 'blended learning' system where e-learning would rationally supplement the actual lectures.

Carrying out RTU student questionnaire it was discovered that the most popular areas are lectures (37%) and the examples of task performances (38%). "Fig. 8". Only 14 % of students use the possibility of self-testing which shows on a rather low level of self-motivation.

The ORTUS environment is a good assistant in the study process of engineering's subjects – 92% of students gave a positive response (Fig. 9), only 4% of students said that ORTUS materials do not help in the study process and 4% said that they do not use them at all.

Designing e-materials, the focus should be on the aspects of didactics, particularly, the ones connected with cognition.

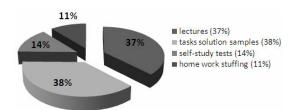Figure 7.   Riga Technical University ORTUS website

Figure 8.   Types of ORTUS teaching materials used in the learning process
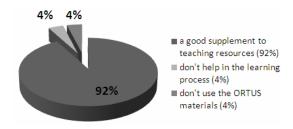

Figure 9.   Students' views on the use of ORTUS material in learning process at Riga Technical University

IV. CONCLUSION

Engineering education should focus not only on the development of professional competences – professional knowledge, professional skills and reflection, but also on social competences - self-competence, co-operation and communication. In order to develop all necessary competences for engineers that would promote their competitiveness in the labour market, the interdisciplinary approach should be implemented in the engineering education.

Professional foreign language plays an important role in the development of communication skills. It is useful to use CLIL (Content and Language Integrated Learning) method in engineering education to integrate professional foreign language. The described experiments carried out at the Faculty of Engineering and the results of the survey among the students show that the students are interested in participation in learning with application of the methods of CLIL in order to improve the acquisition of the content and their foreign language competences.

The role of information literacy competence increases alongside the expansion of ITC. Computer and information competence of students of technical disciplines is a component of information literacy. Developing computer competence, it is important to focus on the acquisition of the knowledge of new computer facilities as well as the knowledge of modern specialized computer programs. Likewise, information competence should not be neglected, where the skill to estimate information critically and competently is significant.

Academic staff should be concerned with the content of the study subject as well as the teaching methods. As a positive case in point, the use of IT software at the LUA in the acquisition of special subjects, where students can perform self-control of individual tasks.

To develop ITC competence, a united e-study environment is important.

However, not only information acquisition is important, assisted by us, academic staff, but also the cognition process of the student himself/herself. One of the main tasks is to teach students to find information by themselves, understand it, be able to apply and remember it (at least temporarily), in a nutshell, to teach to learn individually.

REFERENCES

[1] Dictionary of Foreign Words, Comp. by Baldunčiks J. and Pokrotniece K. Rīga: Jumava.1999

[2] I. Maslo, I.Tiļļa (2005) "Competence as an Ideal of Education and Analytical Category". Skolotājs, vol 3, Rīga,: Zvaigzne, 2005., pp 4-9.

[3] L. Malinovska, A. Zeidmane, J.Abele "Different Aspects and Levels of Competences", Proceedings of the 1st International Conference on Strategic Development of the baltic Sea Region (BSR), 2003 http://ikarus.e-technik.fh-kiel.de/bsn42/index.php?id=45

[4] J.A Keller, F. Novak "Kleines padagogishes Worterbuch", Herder, Freiburg, Germany, 1993

[5] B. Mascarenhas, A. Bavaja, and M. Jamil. "Dynamics of Core Competences in Leading Multinational Companies". California management review, Summer, 1998

[6] K.P. Coyne, S.J.D Hall and P.G. Clifford "Is your core competence a mirage? " McKinsey Quarterly, 1997, pp 40-54.

[7] D.Baumbach "Information skills for the Information Age: The State of Our State", School Library Media Annual, Vol.4., 1984.

[8] T. Pickering "Information Literacy and Information Skills Instruction". Applying Research to Practice in the School library Media Center, 2nd edition, London: Libraries Unlimited, 2004.

[9] A. Asherov, T. Bogdanova. Information culture in engineering education. Proceedings SEFI and IGIP Annual Conference 2007. Copyright 2007, University of Miscolc.

[10] Marsh D., Marsland B., Stenberg K., Integrating Competences for Working Life- Unicom, University of Juvaskyla, Finland, 2001, 262 p.

[11] Malinovska L., Zeidmane A., Mežote A. "Content and Language Integrated Learning – Improvement of Study Process". Proceedings of the 6th International Scientific Conference „Engineering for Rural Development", Jelgava, LLU, 2007, pp 397- 402

[12] Zeidmane A., Malinovska L. "Introduction of CLIL in the Course of Physics", International Research Conference "The Role of Chemistry and Physics in the Development of Agricultural Technologies", Kaunas, 2004. pp. 34 – 44.

[13] ORTUS. www.ortus.lv

AUTHORS

A. Zeidmane and **S.Cernajeva** are with Latvia University of Agriculture, Jelgava, Latvia.