COMPETENCE-BASED ENGINEERING STUDIES

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Abstract. Competence-based studies as one of the topicalities of nowadays higher education are oriented towards labour market demands and flexible adaptation of young specialists to the modern area of professional field and society for sustainable development. The aim of the study was to outline the components of competence-based studies and to analyse engineering students' self-assessment of generic competences at the Latvia University of Agriculture (LLU). As a result of the theoretical study it was possible to determine the following components of competence based studies: development of field-related (professional) competences; development of generic competences consisting of instrumental, systemic, interpersonal and meta competences; link of academic and industry goals in the development of competences; considering of students' needs, particularly cognitive ones; promoting of self-directed studies by implementing transformative learning; usage of modern and updated learning resources. The method of questionnaire was used to investigate the students' self-assessment of their generic competences and preferable teaching methods. The results of the study were obtained from 213 first year and 109 third year LLU engineering students from 2015 to 2017.

Keywords: higher education, components of competence-based studies, self-assessment.

Introduction

Competence-based approach was accepted officially by the Regulations of the Cabinet of Ministers of Latvia in 2008. According to the regulations competence involves analysis, synthesis and assessment. Competence was acknowledged as one of the learning outcomes and included in Descriptors of knowledge, skills and competence confirming to the European Qualification Framework (EQF) levels [1]. The learning outcomes are correspondingly included and explained as an entity of knowledge, skills and competence at the end of the study programme, module or course in the Law of Higher Schools of Latvia [2].

Developers of the Project of Tuning Educational Structures in Europe define learning outcomes as "statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of learning" [3].

The term of competence is approved and defined by the Commission of Terminology of the Academy of Sciences of Latvia as "necessary knowledge, professional experience, comprehension in a specific field or problem, and a skill to use knowledge and experience in a particular action. A person's (employee's) competence is assessed by humans, partners and society" [4].

There was carried out a study in 2016 with a purpose to investigate the usage of terminology in the context of EQF and the Latvian Qualification Framework and to work out suggestions on tuning and explaining of the English and Latvian terms in order to promote comprehension of the importance and objectives of the qualification frameworks in Latvia. The term of competence in the study was defined as a flexible and dynamic entity of knowledge, skills, attitudes, values and emotions for accomplishing of a particular action [5].

Competence based education of the 21st century should consider its vital ideas of pillars of education [6], development of knowledge society and the United Nations Organization aims for sustainable development [7] because they reflect the problem entity of humans all over the world and young specialists should be promoters and developers of the future society. It meets also the European Federation of National Engineering Associations continuing professional development and career strategy demands for engineers in modern working area [8].

Considering the importance of competence-based education in the context of the 21 century challenges the aim of the study was to outline the components of competence-based studies and to analyse engineering students' self-assessment of generic competences at the LLU.

The theoretical significance of the study is in outlining of the components of competence-based studies.

The practical significance of the study comprises the results of engineering students' assessments of their generic competences. The results reflect the students' ability to use knowledge, think

analytically, creatively and autonomously and cooperate. The results could be used in revision and improvement of the competence-based approach towards the study process.

Materials and methods

Competence-based education is a challenge at all levels of education nowadays. Higher education specialists also solve and revise conceptions of competence-based studies on theoretical and practical level. M. Edwards, L.M. Sánchez-Ruiz and C. Sánchez-Díaz [9] mention that current engineering education deals with two problems: fast technological change in the production and management of knowledge and the gap between education and job market requirements. They recognise that competences play a central role in that situation.

The Tuning project fostered revision of higher education system outlining the importance of learning outcomes, competences, educators and students role in the study process. The project distinguished the competences in subject specific and generic ones. The project emphasises the importance of generic competences or transferable skills because they are vitally important for successful employability and citizenship. Therefore, Tuning offered 31 generic competences and distinguished them into instrumental, interpersonal and systemic ones [3].

Nuclear engineering education guidelines on competence based approach in curricula development support the so called “knowledge ladder” including a specified level of knowledge, ability to demonstrate and apply the knowledge, and know when to implement the knowledge. The graduate with the qualification (degree) of Bachelor of Nuclear Engineering for nuclear installations must have the competencies of two categories: general (they include the basic and fundamental areas in which all engineers should have capabilities) and specific in the field of nuclear engineering. Both general and specific competences are acquired by means of the “knowledge ladder”: knowledge, demonstration and implementation [10].

Master’s degree studies also include general and specific competences, but the level of acquiring them is through experimentation, computation and synthesis using the “knowledge ladder”[10].

O.V. Ulyanova, M.V. Morozova, A.A. Nikitin, M.P. Polyanov and S.P. Sopova [11] and M. Bogo, C. Regehr, M. Woodford, etc. [12] in competence-based engineering education substantiate the necessity to develop the qualities related to meta-competence. It means that a person develops abilities to analyse, synthesize, integrate and assess systemically and holistically. Critical reflection is a vital element of meta-competence and is an indicator of an individual’s ability to assess, judge, decide and link together general consequences in professional and everyday situations.

Present society is complex, dynamic and with high knowledge intensity. It means that academics need broad and profound domain-focused knowledge, skills and ability to acquire them and there is a tendency that academic education is becoming more professionally oriented because learning is demanded to be in professional contexts. It means that competence-based education is appropriate to that situation. The students develop learning for life, career, profession and learning to learn. This requires fundamental changes of curriculum [13].

The competence-based approach emphasizes close interaction of higher education with labour market and that type of studies activates appropriate teaching/learning and assessment methods as well as such person’s skills as autonomous and responsible ability to reflect, learning to learn, think critically, be creative and accomplish a task in a high quality. It increases the importance of self-directed studies. Their components serve as one of the means of reaching competence of university studies:

- responsibility and purposefulness (setting of goals and planning) towards studies and chosen professional field;
- active participation in the study process and societal activities;
- continuous cognition and metacognition;
- critical reflection of experience (particularly of learning outcomes and behaviours);
- time management [14].

S. Īriste and I. Katane emphasize the meaning of self-management in the study process and rely it to two aspects of reflection: professional development management and career self-management. The

authors state that reflection is both the process, which serves for the teaching staff as an operative information and control instrument, and the result – acquaints prospective specialists with the macrostructure of self-education and competitiveness development [15].

Self directed studies can be promoted quite effectively by transformative learning with such components as learners' experience, rational discourse, critical reflection and assessment of meanings [16-20].

The survey reflecting the development of engineering students' generic competences had been carried out in 2015 and 2016. There were included ranged answer choices. Students marked high (*h*), medium (*m*) and low (*l*) levels. 150 first year and 109 third year engineering students participated totally in the study. There were compared the data and their difference of significance got from the first and third year students' data using Chi-square in determination of p value ($p \leq \alpha = 0.05$).

The survey on teaching methods with the purpose to clarify the first year 63 engineering students' choices had been carried out in 2017 as well.

Results and discussion

In a result of theoretical studies it was possible to determine the following components of competence-based studies:

- development of field-related (professional) competences;
- development of generic competences consisting of instrumental, systemic, interpersonal and meta competences;
- link of academic and industry goals in the development of competences;
- considering of students' needs, particularly cognitive ones;
- promoting of self-directed studies by implementing transformative learning;
- usage of modern and updated learning resources.

Table 1

Engineering students' self-assessment of generic competences in 2016

Indicator		Respondents		Self-assessment		*p* value
		Year	Totally	*h*	*m* + *l*	
1. Ability to use knowledge, skills and competence in new situations in studies	*n*	1	35	14	21	0.24
		3	27	8	19	0.03
	%	1	100	40	60	-
		3	100	30	70	
2. Ability to think critically, systemically and express an opinion	*n*	1	35	17	18	0.87
		3	27	14	13	0.85
	%	1	100	49	51	-
		3	100	52	48	
3. Ability to analyse, synthesise and assess information	*n*	1	35	15	20	0.40
		3	27	17	10	0.18
	%	1	100	43	57	-
		3	100	63	37	
4. Ability to take decisions and judge on one's own behaviour independently	*n*	1	35	23	12	0.06
		3	27	21	6	0.00
	%	1	100	66	34	-
		3	100	78	22	
5. Ability to cooperate with others	*n*	1	35	28	7	0.00
		3	27	22	5	0.00
	%	1	100	80	20	-
		3	100	82	18	

The Latvia University of Agriculture engineering students' self-assessment of generic competences had been carried out using a questionnaire with a scale *h* – high; *m* – middle and *l* – low.

Processing the primary data it was found that the frequency of the responses *low* was less than 5. Therefore, the responses *middle* and *low* were merged together (Table 1 and Table 2). By *p* value were stated *h* and (*m* + *l*) indicators of significant differences of each year. It was done by interactive calculation tool [22].

In the study done in 2016 (Table 1) in the percentage distribution of responses in the fourth indicator *ability to take decisions and judge on one's own behaviour independently* assessments *high* dominate in the third year ($p = 0.00$) as well as in both years in the fifth indicator *ability to cooperate with others* ($p = 0.00$). It, of course, is a positive trend but there are no further studies why it is so.

Actually, it means that the mentioned indicators (generic skills) are developed at the Latvia University of Agriculture, particularly *taking decisions and judging on one's own behaviour independently* because it is higher for the third year students than for the first year students.

Assessments *m* + *l* dominate in the first indicator *ability to use knowledge, skills and competence in new situations in studies* ($p = 0.03$) for the third year students. It means that student abilities are relatively low developed and there are necessary further studies to find out the causes and reduce them.

Table 2

Engineering students' self-assessment of generic competences in 2015

Indicator		Respondents		Self-assessment		*p* value
		Year	Totally	*h*	*m + l*	
1. Ability to use knowledge, skills and competence in new situations in studies	*n*	1	115	37	78	0.00
		3	82	23	59	0.00
	%	1	100	32	68	-
		3	100	28	72	
2. Ability to think critically, systemically and express an opinion	*n*	1	115	39	76	0.00
		3	82	38	44	0.51
	%	1	100	34	66	-
		3	100	46	54	
3. Ability to analyse, synthesise and assess information	*n*	1	115	50	65	0.16
		3	82	40	42	0.83
	%	1	100	43	57	-
		3	100	49	51	
4. Ability to take decisions and judge on one's own behaviour independently	*n*	1	115	68	47	0.05
		3	82	52	30	0.02
	%	1	100	59	41	-
		3	100	63	37	
5. Ability to cooperate with others	*n*	1	115	77	38	0.00
		3	82	59	23	0.00
	%	1	100	67	33	-
		3	100	72	28	

In the study done in 2015 (Table 2) the differences of the respondents' answers are particularly explicit in the fifth indicator *ability to cooperate with others* for both years ($p = 0.00$) and in the fourth indicator *ability to take decisions and judge own action independently* (for the first year students $p = 0.05$; for the third year students $p = 0.02$) – there assessments *high* dominate.

Assessments middle and low dominate in the first indicator ability to use knowledge, skills and competence in new situations in studies ($p = 0.00$) and in the second indicator ability to think critically, systemically and express an opinion for the first year students ($p = 0.00$).

As there was a lack of further studies on causes of low and middle results, 63 first year engineering students in September 2017 were questioned about the teaching methods they prefer. The students first and foremost mentioned practical and group work, and the usage of IT. They also mentioned lectures and projects, but they were not the dominating methods. It means that the students recognise interactive methods and cooperation with academics. It is a challenge for many academics because many of them use to deliver the lectures and are not happy of interactive methods but nowadays the situation is different even from the situation a few years ago and the academics should be motivated to change their teaching style. In the case of competence based studies the interactive methods promote equal development of both professional and generic competences.

Competence-based studies are outlined in the Spanish case in curricular development in electronic engineering. The most important areas within the curriculum were stated by means of the survey applied to 994 employers, 2085 graduates and 1423 academics. They marked the following generic competences as vitally important: problem-solving (ability to identify, formulate, and solve engineering problems); decision-making; planning, coordinating and organizing; ability to apply knowledge in practice; team-work; motivation for quality and continuous improvement; capacity of analysis and synthesis, and leadership [9].

Competence-based education (CBE) developed in the USA college education met a lot of challenges. USA education policymakers recognize the importance of the postsecondary education because it is vital in a person's individual success. There was the Obama Administration announcement in 2013 on innovation in higher education and competence-based education (CBE) was developed in college education following the four principles:

- the degree reflects robust and valid competencies (competences are the base of CBE curriculum and they are focused both on academic and industrial goals in professional programmes);
- students are able to learn at a variable pace and are supported in their learning (the students are allowed to reach their progress at an individualized pace because there are differences in their skills and knowledge at the beginning of the curriculum; they receive academic and other kind of support to keep progress of their learning outcomes);
- effective learning resources are available any time and are reusable (the learning resources should be of high quality and usable at any level of difficulty; they should be matched to the course objectives and technological opportunities and updated regularly);
- the process for mapping competencies to courses, learning outcomes, and assessments is explicit (the topics of the courses should be of appropriate length and complexity to get an expected competence; the appropriate assessment methods and learning resources should be selected; the process of the curriculum development should be matched by all involved academics);
- assessments are secure and reliable (expertises both from industry and academicians are carried out to assess the content of the curriculum, and pilot testing is practiced as well; the student assessments are in various forms and in multi-choice assessments they receive a feedback immediately) [22].

The principles help strengthen the link of education with the labour market and they also help to revise the quality of higher education from "inside".

Conclusions

1. Competence-based studies is a challenge for educating the 21st century young engineering generation because on the one hand there are nowadays demands for professionals including sustainability, professional and generic competences for modern working area, and on the other hand academics have to adapt to more interactive teaching/learning methods and promote the students' self-directed studies by means of transformative learning.
2. Consideration of the components of competence-based studies such as: development of field-related (professional) competences; development of generic competences consisting of instrumental, systemic, interpersonal and meta competences; link of academic and industry goals in the development of competences; considering of students' needs, particularly cognitive ones;

promoting of self-directed studies by implementing transformative learning and usage of modern and updated learning resources should promote the development of professionals who could be able to meet the demands of changing the labour market and working situation in the world in general and adapt to vitally changing situations.

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