MIDDLE POMERANIAN SCIENTIFIC SOCIETY OF THE ENVIRONMENT PROTECTION

Rocznik Ochrona Środowiska

Volume 21. Year 2019 ISSN 1506-218X 69-84

Sustainable Development Approach in Environmental Engineering Study Programmes

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1. Introduction

Sustainable development is still an actuality in all the fields of living. Among 17 Global sustainable development goals (SDGs) new areas came into effect in January 2016. Such areas as climate change, sustainable consumption, economic inequality, innovation, quality education, peace and justice will have significant consequences for national development planning in both developed and developing countries in the period of 15 years starting from year 2015 (Allen et al. 2016). Allen et al. (2016) discuss scenario analysis and quantitative modelling as important analytical tools to support national sustainable development planning and an available tool to decision makers.

The United Nations declaration of the Decade of Education for Sustainable Development (UN DESD) advocates the need for universities to embed sustainability in all learning areas (Bina et al. 2016). Bina et al. (2016) examines how selected post-graduate top-level programmes in urban studies are adapting their curricula to promote sustainable urban development. There is reviewed extensive literature and identified the principles and practices characterising the UN DESD, topics and themes considered essential for teaching, aimed at the promotion of sustainable urban development. Based on this literature review there has been defined an analytical framework in five parts, related to various aspects of curricular content and teaching and learning approaches: programme orientation, skills, ethics and critical reasoning, interdisciplinary and content related to sustainable urban development issues.

The higher education institutions (HEI) the DESD advocates the need to address the complexity of current real-world contexts by embedding sustainability in all learning areas across university curricula.

UNESCO (Nations 2014) states that a full integration of sustainable values into higher education systems has yet to take place in most countries, the further efforts should be implied that sustainability and sustainable development become an integral part of the academic culture. Education for sustainability is still lacking a consistent interdisciplinary conceptual framework (Jabareen 2012).

Chin & Jacobsson (2016) state that global sustainable development is the challenge that defines our time. SDGs will only succeed when they are owned by every citizen in the world, and when everybody is empowered to become change agents.

As Holm et al. (2015) state sustainability aspects in higher education must be enhanced with more concrete actions. Universities are globally required to have quality assurance to secure and improve teaching and learning, and they use management systems for this aim. Integrating education for sustainable development and management systems are alike in that they are based on continuous improvement and systematic thinking; for both processes all stakeholders need to be involved. Although quality assurance is compulsory for higher education, education for sustainable development has barely been examined or integrated in this context. The research examines how voluntary integration of education for sustainable development into management systems at universities could facilitate a scheme to overcome the challenges to integrating education for sustainable development that were identified in previous research. A process framework for integrating education for sustainable development with management systems was developed in a network of 11 universities in the Nordic countries. The framework included planning, assessment, monitoring, and implementation of education for sustainable development. It was piloted and applied to identify relevant sustainability aspects in different disciplines, examples of which are provided in the article. The framework can be applied to visualize the implementation of education for sustainable development.

As companies and other organizations increasingly recognize society's demand for greater social and environmental sustainability, university and college business schools have responded with new pedagogic approaches. Business schools have begun to offer courses in business models and business model innovation that focus not only on profit-normative goals but also on social and environmental goals. This paper describes an Experiential Workshop where the students take the role of problem-owners and problem-solvers as they co-create new business models ideas for the cooperative. The paper presents the students' achievement of three Learning Objectives as they engage in meaningful, "real-world" simulations with a high degree of autonomy that allows them to combine their theoretical knowledge with practice. Implications for educators who wish to test the Experiential Workshop in their classrooms are proposed. The

paper concludes with the suggestion that Education for Flourishing is a useful expansion of the ESD (Hoveskog et al. 2017).

Kankovskaya (2016) analyses the spread of the concept of sustainable development in Russian higher education as a subsystem of the national innovation system. There have been analysed state educational standards and educational programmes of universities and identified problems in the implementation of the concept of sustainable development in Russian higher education, and formulated principles for the national innovation system based on the concept of sustainability (Kankovskaya 2016). The aim of this paper was to formulate the principles of development of national system of innovation (NSI), and higher education as the main subsystem in NSI, based on the concept of sustainable development, taking into account the current state of higher education in Russia. Priorities are formulated for the development of a sustainable approach to Russian higher education, including incorporation of principles of sustainable development in the main part of educational programmes as general cultural or general professional competences, an inter-disciplinary approach and inter-faculty integration in the realization of educational programmes. Identified problems suggest that it is advisable to devote time in further studies to examining the constraining factors in the development of higher education for sustainable development.

One of the sustainable development goals is sustainable consumption and production policy (Liobikiene & Dagiliute, 2016), which is a key objective in the renewed European Union (EU) Sustainable Development Strategy (SDS). SDS targets are concerned more with production than consumption side. Three main aspects: smarter consumption, better products, as well as global markets for sustainable products are highlighted in SDS.

The change of energy policy and the overall energy consumption model presumes a holistic approach which should consider and manage a series of parameters such as technology, the economy, politics, society and education (Ocetkiewicz et al. 2017). The paper presents the results of research related to the evaluation of Polish teachers' experiences working in lower secondary schools (3rd stage in the Polish educational system) in terms of education for sustainable development. Unfortunately, the research has shown that Polish school teachers are not well prepared for the inclusion of key issues of sustainable development in school curricula. They are neither aware of the need for those issues to be considered, nor take responsibility for them knowing that sustainable development is the predominant economic, social, and environmental doctrine in Europe and in the world. The teachers know neither the educational principles behind sustainable development, nor their priorities and the objective of promoting a better and multifaceted understanding of the issues which our

civilization faces. Teacher training is necessary, as well as raising the teachers' awareness of the principles of sustainable development and changing their attitudes towards it, not only at the school level, but also in everyday life.

Marta et al. (2018) state that High Education Institutions (HEI) play an important role in the promotion of sustainability and an increasing number of stakeholders expect them to be sustainable organizations. Marta et al. (2018) have investigated how the main stakeholders (leaders, faculty, staff, students, and external stakeholders) of Public HEI perceive: the concepts of sustainability and sustainable HEI, the role of higher education for sustainable development, and the barriers, challenges and obstacles to implementing sustainable initiatives in Public HEI. The qualitative approach, using semi-structured interviews and content analysis procedures are applied to explore the perspectives of stakeholders from Public HEI. The results suggest that, although aware of the concept of sustainability, the different stakeholders are not familiar with the concept of sustainable HEI. The lack of financial resources due to the decline in funding for higher education and falling numbers of Portuguese university students is perceived as the main barrier to sustainable development in higher education (i.e. practices are still associated with spending financial resources). This research highlights the importance of a conceptual and organizational change in HEI, notably through identifying new sources of financing, more flexible organizational forms, more comprehensive mission statements, more tailored educational offers, life-long learning and commitment to internationalization, and more strategic human resource management. The present article reviews how HEI could promote sustainability, the main concepts underlying this subject, and the way higher education for sustainable development is understood and could be improved in Portuguese HEI. Finally, raising more funding, attracting more students, transferring knowledge, promoting quality and excellence, and increasing the internationalization of HEIs seem to be the most prominent issues for the future of HEIs. It is suggested further to make the research on identification of sustainability practices already being implemented in HEIs, taking into account: the four pillars of sustainability (economic, environmental, social, and institutional) and the core activities of HEIs (education, research, operations and community engagement).

2. Methods

All the students from Environmental Engineering Faculty of Vilnius Gediminas Technical University (Lithuania) (attending Energy and Water related courses on the second and third years of study in autumn and spring semesters) were instructed about the survey of the quality of studying. Totally 148 students were divided into working teams approximately up to 20 people in

each group and all the students answered their questionnaires used for study quality improvements and new curricula development, new knowledge obtaining, lecturing, knowledge used in related practice and other related activities. All the answers were estimated annually, daily and each semester following the results obtained by the students. All the students attended an online survey situated near the university study programmes. The students' answers were related with all theories, some exercises, laboratory works and industrial facilities. All the students were involved in water and energy related projects design, quantities measurements on used energy and water flows. Working teams in the second and third academic years were involved in answering their questionnaires separately with possibilities to evaluate improvement needs following age indicator. Some working team members were absolute "leaders" in answering all the questions and their explanations were related with high load of some exercises or laboratory equipment treatment.

Open presentations on survey progress were carried out annually and according to each semester mostly related to knowledge exchange and corrections of obtained mistakes. All responsible lecturers were advised to estimate statistically approved maximum, minimum and average numbers of the answers and related quantities. Some comparison techniques were in use when evaluating different demand for survey following related activities (study time - schedule, exercises, laboratory equipment treatment etc.). Finally, after last discussions by the end of the academic year we obtained the finished reports on study improvement and possible changes in different courses balanced on annually, practically used and possible academic loads quantities.

Some similarities in different answers for lecturing and practical exercising were obtained in surveys and nearly all the studying groups agreed on possible use of the questions or this survey of study programme improvements. All possible study improvements were carefully estimated and best practice examples taken from each survey to quantitative analyse using software equipment related to analysing of the students' answers, reliability and obtained feedback. The answers obtained by every student, were valid for one semester, two and 3 semesters, imitating possible changes in related improvements and all the changes in study quality were recorded and compared.

Students follow a structured timetable prepared at the Faculty level taking into account the lecturers' timetable and suitability to students' needs. The study process attempts to address a balance between academic subjects, research and skills development and encourages systematic independent work by the students. The study process is regulated by Studies Regulations and the annual plan of study.

3. Results

Investigated Study programme started at University first cycle Bachelor' s studies at Faculty of Environmental Engineering. Official length and form of programme (length in years): 240 ECTS credits, continual studies for four-year studies.

Study programme aims were - to educate professionals who, after they have acquired knowledge while studying the general subjects, basic subjects and specific subjects of university studies, would be able to analyse, model and simulate the energy conversion processes, to identify, formulate and solve the engineering problems related with heat production and conversion, water supply, gas supply and consumption, as well as with indoor air quality, while planning, designing, using new and available energy, thermal equipment and systems, which exhibit high efficiency, cost effectiveness, quality and reliability of energy conversion, consumption and management in a coherent and sustainable demand for resources and environmental impact. Prospective study programme results are described in Table 1.

Professional outcomes: Graduates are employed in heat or water supply, heating, ventilation and air conditioning design, maintenance and production companies; or continue education for Master's degree.

Study programme was updated while implementing 2010-2012 means of Human Resources Development Programme priority 2 “Lifelong Learning” VP1-2.2-ŠMM-07-K, “Improvement of study quality, increase in internationalisation” project “Updating of Study Programmes in Sustainable Living Environment Area of Studies, Strengthening of Interdisciplinary Interaction Applying Innovative Learning Methods and Introducing the Concept of Sustainable Development”. The main aim of the project was to update five first cycle study programmes at the Faculty of Environmental Engineering. Innovative teaching methods, problem-driven teaching, systematic thinking were sought to apply in majority of courses, at the same time granting students’ knowledge of environmental sustainability, its implementation principles, application of advanced technologies. The first objective of updating the study programme was to undergo transition to ECTS credits system, edit the learning outcomes, relate them to courses and create new module cards for course units. The description of 21 modules was created in the Moodle medium while updating the study programme. Study material consisting of 6 modules was prepared to the principles of sustainable living environment. There were created problem-driven teaching materials consisting of two modules.

Table 1. Prospective study programme results

Knowledge	Research skills	Special skills	Social skills
Knowledge of fundamental sciences, nature and its phenomena.	Understanding of laws of fundamental sciences and natural sciences and possibilities of their applicability in professional activity.	Ability to apply knowledge and understanding of the boundaries of production, conversion and use of non-renewable and renewable energy sources, their structure, properties, function, components and processes of interaction, the overall integrity of these systems, their interaction with environment, independently identifying, formulating and addressing the specific environmental engineering problems.	Knowledge and understanding of phenomena in a field of environmental engineering, ability to apply the information of fundamental, social, humanitarian sciences and other technological sciences.
Knowledge of humanities and social sciences to develop the erudition and philosophic outlook.	Understanding of principles of humanities and social sciences and their application in engineering.	Ability to collect, interpret and process the data using computer technologies required to tackle the tasks and challenges in the area of energy engineering, having the skills operating the measuring equipment and laboratory skills working with related equipment.	Knowledge and understanding, ability to formulate and reasonably justify the own decisions, demonstration of a motivated and responsible attitude to their profession.
Knowledge of general basics of technological sciences	Understanding of new and significant problems of researches and development in a field of technological sciences.	Ability to transfer information, ideas, problems and solutions, to reason them, to defend against audience of professionals.	Ability to properly collect, use and interpret data, provide explicit and consistent responds to particularly defined problems and challenges in the field of environmental engineering.

Table 1. cont.

Knowledge	Research skills	Special skills	Social skills
Knowledge of basics of trend of environmental engineering studies.	Understanding the basics of trend of environmental engineering studies.	Skills of self-development, self-learning necessary to continue studies in the next cycle, ability to make rational decisions in the field of environmental engineering, to apply the acquired theoretical knowledge in practice considering the aspects of energy efficiency, energy safety, economics and environmental impact.	Ability to communicate at least in one of the main foreign languages, use modern information and communication technologies, skills to operate in a multi-disciplinary team.
Special knowledge of trend of environmental engineering studies.	Understanding of traditional and innovative technologies of environmental systems and their application methods. Understanding of principles of sustainable development, having a holistic approach to engineering solutions, combining the costs, benefits, safety, quality, reliability and impact on environment.		Ability of learning and self-development, ability to plan and organize professional life, a holistic approach to processes going in the field, contiguous areas and in general society, understanding and ability to explain the principles of sustainable development, ability to assess and forecast the phenomena, their causes and consequences.

Reviewing of study results is overseen by each study programme committee and faculty committee for studies. Social stakeholders and students are also involved in the reviewing process as members of both committees. To receive the feedback the cooperation with graduates, employers and associations is performed, Alumni club is created, student surveys are continuously carried out. Based on such cooperation the needs of the interested parties are determined and considered when learning outcomes of the programme are reviewed. To have a particular course responsible lecturers make an annual review of the contents and improve them if it is necessary. Before starting to deliver a course, lecturers present students with updated detailed course descriptions.

Involvement of students in research and practical activities is facilitated through team work with projects in some of the study subjects, conducting research practice and through their final thesis.

Having acquired practical qualification, students can seek employment as qualified specialists or work in a managerial position in companies, which produce heat or supply water, deal with building, engineering companies that design, install engineering systems or industrial and public buildings with maintenance of these systems.

In order to be qualified for the abovementioned positions, students must meet the following requirements: – abilities to determine and solve problems related to heat production, transformation, supply of heat and water, exploitation of the economy of this sector, as well as engineering problems related to indoor air quality by using modern engineering measures in heat production, transformation, supplying and exploitation of heat and water and indoor air quality engineering systems, designing projects for heat production, transformation, supply and exploitation of heat and water and indoor air quality engineering systems, carrying out research into their impact on economics and environment, using informational technologies to solve problems of general and special engineering activities.

Main results of the survey of Industrial Practice are presented in Table 2.

The results of the survey of Ventilation course with project and laboratory works are presented in Figure 1.

Assessment criteria of students' achievements by Assessment levels is applied to all students.

The threshold assessment (5-6). Has basic knowledge of ventilation methods, equipment and systems, and their design and operation principles, and has a fragmentary understanding of their interconnections with related fields of knowledge, but lacks the ability to apply them. With the assistance of a teacher is able to perform and defend ventilation laboratory works in accordance with the given descriptions, has initial skills using measuring equipment, but they are

demonstrated with the teacher's encouragement. Is able to carry out standard calculations of ventilation system design, select equipment using the method, tool and software offered by the lecturer, but the lecturer must encourage to demonstrate these abilities.

Table 2. The results of the survey of Industrial Practice

Career Practice	Year		2013	2014	2015	2016	2017	2018
Company size	1-249 employees	percentage	65.71	51.61	78.05	73.33	77.14	80.00
	250 employees		34.29	48.39	21.95	26.67	22.86	20.00
Workloads	qualified		50.00	25.81	63.41	60	71.43	70.00
	assistance		50.00	74.19	36.59	40	28.57	30.00
Workloads related to Study Program	Very good		30.00	35.46	26.83	46.67	45.71	70.00
	good		50.00	35.50	46.34	46.67	42.86	15.00
	satisfactory		17.00	25.81	26.83	6.66	8.57	15.00
	Not applied		2.00	3.23	0.00	0.00	0.00	0.00
	Can't answer		1.00	0.00	0.00	0.00	2.86	0.00
Useful practical knowledge	Very useful		44.29	45.16	56.10	53.33	68.57	70.00
	useful		44.29	40.32	31.70	46.67	31.43	25.00
	satisfactory		8.57	11.29	12.2	0.00	0.00	5.00
	Non-useful		2.85	3.23	0.00	0.00	0.00	0.00
	Can't answer		0.00	0.00	0.00	0.00	0.00	0.00

The typical assessment (7-8). Has a good knowledge of ventilation techniques, systems and elements, knows the design and operation principles, limited to study materials, is able to connect this knowledge with the knowledge of related fields and apply it in practice in new business situations. Is able by itself to carry out and defend the ventilation laboratory work, in accordance with the descriptions, is able to explain it based on study literature, possesses initial skills in using measuring equipment and demonstrates them during the classes. Is able by itself to choose the appropriate method, tool, software used for ventilation design calculations and equipment selection, explain them on the basis of study literature, demonstrates the abilities during the classes.

The excellent assessment (9-10). Has very good knowledge of environmental techniques, systems and elements, knows the principles of designing and operating them, not limited to the study material, is able to systematically associate this knowledge with the knowledge of related fields and apply it creatively in practical situations. Analysing the solutions of ventilation systems, they are critically evaluated in the context of changing technologies. Is able by itself to quickly perform and defend the ventilation laboratory works, reasonably explain their theoretical and practical significance based on the literature not limited to

the study material, has skills in measurements and usage of measuring equipment, demonstrates skills in cooperation with other students during the classes. Is able by itself quickly and accurately select the appropriate method, tool, software used for ventilation design calculations and equipment selection, as well as reasonably explain their theoretical and practical significance based not only on study materials, demonstrates the abilities in cooperation with classmates during classes.

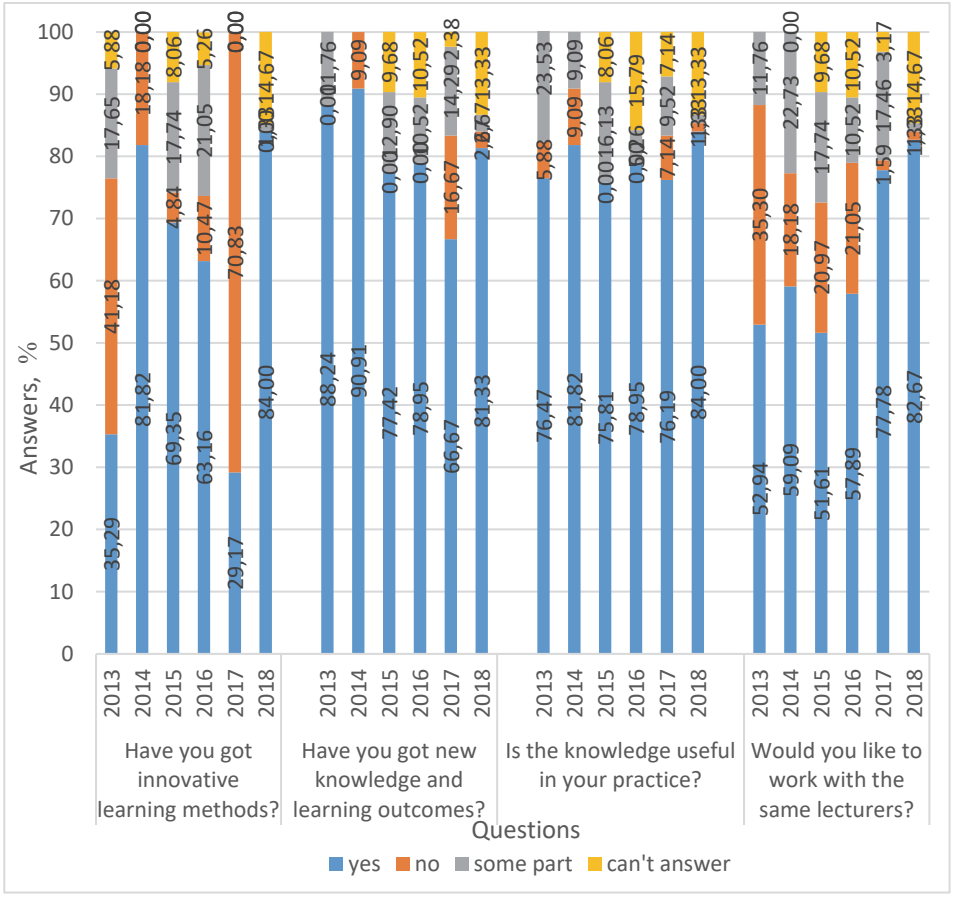

Fig. 1. The results of the survey of Ventilation course with project and laboratory works

The results of the survey of Building Services Systems course are presented in Figure 2.

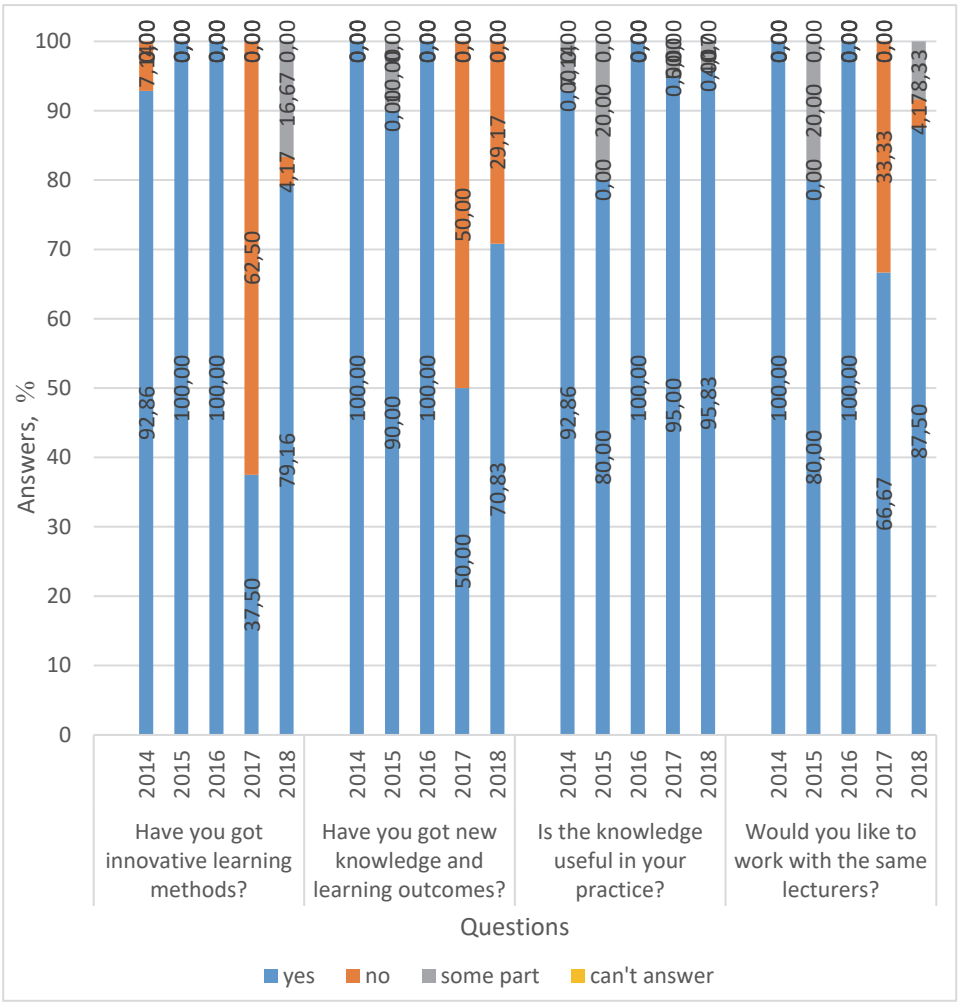

Fig. 2. The results of the survey of Building Services Systems course

Evaluation criteria for knowledge assessment were according to the threshold levels.

The threshold assessment (5-6).

Basic knowledge about water related systems design, fragmented understanding of connection between different subjects without ability to apply. Able to self-selection of useful design methods and under lecturer's control can evaluate design stages and analyse results.

The typical assessment (7-8).

Good knowledge about water systems related elements with limited study knowledge, able to connect similar knowledge and apply to a practical new situation. Able to use background study literature to plan, select a useful design method, to analyse and critically evaluate obtained results.

The excellent assessment (9-10).

Excellent understanding about water related systems without limits to study materials, able to connect with similar knowledge of systems design and creative thinking to practical activities. Able to apply newest scientific literature to the calculations and to evaluate water related systems design, trends, analysis, interpretation and connection with presented elements.

The results of the survey of Fluids Machinery course with laboratory works are presented in Figure 3.

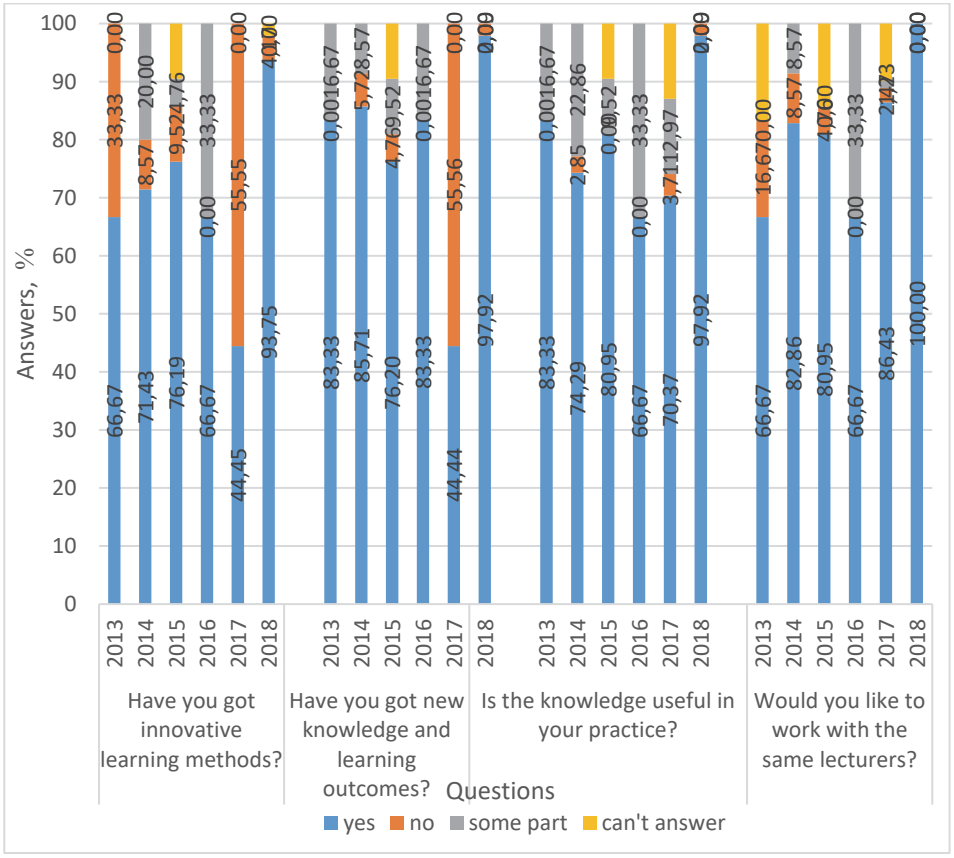

Fig. 3. The results of the survey of Fluids Machinery course with laboratory works

The threshold, typical and excellent assessment marks were made according to obtained knowledge and professional skills.

The threshold assessment (5-6)

Has basic knowledge of fluid supply systems and background of their hydraulic calculation. Is able to do simple hydraulic calculations of water and water heating supply systems, choose fluid movers that are needed in a way, that teacher suggests, has initial skills for using measuring devices, but only demonstrates them after being encouraged by teacher. Is able to choose the appropriate method and solve problems of hydraulic systems while supervised by teacher, understands how they are related with practical examples presented.

The typical assessment (7-8)

Has a good knowledge of the properties of fluid (gas) supply systems and their structure, knows methods of their hydraulic calculation. Is able to do hydraulic calculations of water and water heating supply systems and apply fluid movers by choosing the right way himself, has basic skills for using measuring and control devices and demonstrates them during classes. Using scientific / study literature, is able to plan, choose the right method, investigate and solve problems and tasks of hydraulic systems, analyse obtained results, relate them to practical examples presented.

The excellent assessment (9-10)

Perfectly understands principles of hydraulic calculations of energy and water supply systems and bases of application. Without being restricted to the study material, is able to systematically associate this knowledge with the knowledge of related areas and apply it in practical situations in a creative way. Is able to solve the problem by precisely selecting the appropriate method for performing hydraulic calculations of water and water and heat supply systems, analyse the results and explain their theoretical and practical significance in a reasoned way, based not only on literature used during studies, has skills to use measuring and control devices and demonstrates them in collaboration with other students during classes. In accordance with the latest scientific literature is able to perform accurate calculations of environmental systems tasks, to critically evaluate the results, interpret and associate them with the practical examples presented, to present their conclusions written and verbally during classes.

4. Conclusions

1. In the light of the above results of the surveys, the Programme is constantly developed while maintaining its high quality and competitiveness among other study programmes, all the more so the present study has been launched by double-diploma education system from this year onwards.

2. The programme should have more specific intended learning outcomes consistent with the specific focus on the programme relating the general aspects to those provided by the study subjects. Some of the study subjects intended learning outcomes should be revised to reflect the level of studies.
3. Practical work for students in companies throughout all years of study including visits to different companies after the first year and inviting experts from industry to present lectures to students provides a good link with industry and improves student's awareness of practical issues and opens opportunities for employment.
4. Students' feedback reflected a high level of satisfaction with their experience, good engagement and understanding of the opportunities offered them by the degree.
5. The programme intended learning outcomes should be re-cast to be more specific to the programme rather than the general form presented. It is also concluded that the programme should continue to develop to meet the modern needs of sustainable development reflecting also the need of the country to comply with the European Union and international obligations.

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Abstract

Completed integration of sustainable values into higher education systems has yet to take place in European Union countries, the further efforts should be implied that sustainable development become an integral part of the academic culture. Education for sustainability is still lacking a consistent interdisciplinary conceptual framework all around European countries. Investigated Study programme of Environmental Engineering for the Sustainable Living Environment was carried out at Vilnius Gediminas Technical University (Lithuania) first cycle Bachelor's studies at Faculty of Environmental Engineering. Involvement of students in research and practical activities was encouraged through team work with projects in all related study subjects, providing research practice and through their final thesis. Students feedback reflected high level of satisfaction of their experience in sustainable development topics, reliable engagement and understanding of the opportunities offered to them by Study Programme related to Sustainable Living Environment topics.

Keywords:
sustainable development, study programmes, education,