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IMPLEMENTATION OF NATIONAL HIGHER EDUCATION STANDARD IN ELECTRONICS: STUDENTS' PERCEPTIONS OF LEARNING OUTCOMES

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Abstract

Recently, Ukrainian higher education institutions (UHEI) have undergone major changes in revising and implementing new policies, concerning the outcome-oriented reform in the national higher education standards (NHES). This paper describes research, conducted in Ukraine to collect the data on how new NHES in Electronics and program-based outcomes are perceived by undergraduate engineering students' in terms of achieving their learning outcomes. The results of the study suggest that while the importance of implementing outcome-oriented initiative is highly supported and documented by the UHEI, students do not see the clear relation of program-based outcomes to the acquired knowledge and skills. Regardless of their apparent unawareness of program-based outcomes, students claim to be able to demonstrate their acquired knowledge and skills in practice, which is supported by self-assessment of their progress as well as the data on students' average grades. Additionally, the study shows that program-based outcomes are rarely used to assess students' performance as the outcomes do not align with the assessment criteria. The study indicates that students' awareness of higher education learning outcomes, based on NHES in Electronics Engineering (EE) programmes, is generally underestimated both by students and course developers. The results unveil the need to introduce a professional development program in order to train EE course developers to adequately implement NHES outcomes in designing EE courses as well as make existing assessment criteria outcome-oriented.

Keywords: engineering education, electronics engineering courses, higher education learning outcomes, national higher education standard, students' perceptions, Ukrainian higher education institutions.

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1. Introduction

In 2014, the new Law on higher education has introduced a number of challenges to Ukrainian academia [1]. Along with these changes, Ukrainian higher education institutions have been actively engaged in shaping their policies and documents in order to conform to revised approaches to R&D, innovations and international cooperation, management and organization of the educational process, degrees and qualifications in higher education as well as quality assurance, control, and educational standards. According to the Ministry of Education and Science of Ukraine, more than 30 new educational standards have been developed and implemented by Ukrainian universities by academic year 2018/2019, and the number is increasing. In the new policy-driven national standards, learning outcomes have become a central issue for outlining students' knowledge and skills within a specific degree. What is not yet clear is the impact of NHES and its higher education learning outcomes (HELO) on university educational programs and syllabi.

There have been a number of longitudinal studies of international practices in HELO, focusing on the role of HELO in the 21st century, national contexts and experiences as well as the assessment of HELO [2, 3]. Similarly, there is a large volume of published studies, reporting about national experiences in implementing the Organisation's of Economic Cooperation and Development (OECD) international assessment of HELO [4, 5].

Zlatkin-Troitschanskaia et.al (2016) note that outcome-oriented reform strategies, introduced by a range of policymaking bodies like OECD, the European Association for Quality Assurance in Higher Education (ENQA), conditioned long-term changes in the country. Authors argue that "These changes can be attributed in part to the immense increase in access to higher education and to the effects of internationalization of study programs and mobility of students.

These changes have led to an urgent need for international benchmarking standards to provide evidence of student learning outcomes in higher education that can be compared across institutions and countries" [6]. While some research regarding HELO has been carried out internationally, there is a little scientific understanding of the interrelation of the NHES and HELOs in Ukrainian higher education context.

The purpose of this study is to examine NHES in Electronics Engineering in the context of its influence on program-based outcomes, to obtain data of students' perceptions of learning outcomes in order to address the existing program-based outcomes and develop an understating of how students' perceptions of learning outcomes can be used to improve the electronics engineering courses.

2. Methods

In most recent studies, students' perceptions of learning outcomes have been measured both qualitatively and quantitatively. The study uses mixed-methods in order to gain insights of participants' views. Supporting Cresswell's (2014) claim that if the study aims to incorporate perspectives of individuals, we used embedded mixed methods [7].

There were 67 participants in the sample, who were interviewed through the Google Classroom Questionnaire tool. For this study, we interviewed Ukrainian undergraduate students from the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Faculty of Electronics (EE programme) in order to analyse their perceptions of course learning outcomes. The first step (questionnaire) aimed to identify the aspects i.e. course organisation, content, delivery etc. that can be improved, and the second step can-do statements demonstrated whether students can critically identify the NHES outcomes through the program-based outcomes in the subjects, learnt within their undergraduate course.

3. Results

The content of education is a historical category that is designed to fulfil the social demand of the society, that is, to meet the requirements of society for training the required specialists. Since with the development of society, the needs for the level and quality of training of future specialists change, the content of education is being constantly updated, that is, it is a variable. The content of education is influenced by several factors, which can be conditionally divided into two categories: objective and subjective. The group of objective factors includes the development of science and technology, generating of new ideas and creating new knowledge, the needs of society; subjective factors, in turn, reflect the direct influence of certain categories of people and organizations in society, e. g., the state educational policy, scientists' vision etc. [8, p. 137].

In pedagogical resources, the concept of the content of higher education is interpreted from a didactic perspective. It is regarded as scientific information that is necessary to study, pedagogically grounded, logically designed, reflected in educational documentation that regulates the learning process in any higher education institution (HEI) [9, p. 345].

At the same time, N. Batechko points out that educational professional programs and curricula development should comply with modern scientific principles, that is, not to be just a list of academic disciplines, but to ensure their cyclicity and continuity [10, p. 8]. According to the scholar, in modern pedagogy, a system of didactic principles for the development of higher education content has been formed, and consists of two groups: general didactic principles (scientific nature of education and training; unity of theory and practice, education and training; systematic character and consistency; developmental and educational nature of training; accessibility; structural unity of the subject and procedural aspects of the education content; the relationship of content, forms and teaching methods); and specific principles for the formation of the professional training content (consistency of the education content with the goals of future specialists' training, as well as the main types of specialists' professional activities; principles of advanced (predictive) nature of the content of education; principles of taking into account the patterns of professional development).

The Ukrainian higher education legislation sees the educational program as a system of educational components at an appropriate level of higher education within a specialty, which determines the requirements for the level of education of applicants, who can start training in this program, the list of academic disciplines and the logical sequence of their study, the number of ECTS credits, required to complete this program, and also the expected learning outcomes that an applicant for the relevant higher education degree must master [1].

The educational program serves as the basis for the development of a curriculum, which determines the list and volumes of academic disciplines in ECTS credits, the sequence of studying disciplines, forms of training sessions and their volume, schedule of the educational process, forms of formative and summative assessment [11, p. 9].

Since our previous study [12] identified US engineering education as the leading one with regard to training electronics engineers, our study will address both US and Ukrainian higher education contexts in developing electronics engineering courses in order to outline potential aspects to apply in the Ukrainian context.

US concepts of higher education are introduced by the Higher Education Opportunity Act (2008) [13]. Similar to the Ukrainian context, US educational programs and curricula are normally posted on the US universities websites. However, one of the distinctive features of the US higher education system in this regard is that the institution offers only a recommended curriculum with distribution and sequence of disciplines. Applicants form their training plans independently, that is, they choose the list and sequence of the disciplines, but following the program requirements.

As the content of electronics engineering courses is reflected in the educational documentation and is regulated by it, it is expedient to study the features of educational content development for the electronics specialists in the United States, based on the analysis of educational programs and curricula of leading higher educational institutions that provide training for specialists in this area.

The study found that, in general, US educational and professional programs were formed in accordance with "Engineering Competency Model", developed by the Employment and Training Administration of the United States Department of Labour [14]. It outlines the set of knowledge, skills, abilities and attitudes, required from engineers to carry out effective professional activities.

Generally speaking, it presents two groups of competencies – generic and industry-specific ones. Thus, the generic ones include thee subcategories. The first one is personal effectiveness competencies or so-called "soft skills", which provide interaction and good relations between people, and which are acquired in family and society, and are improved during training and later in the professional environment; the second one – academic competencies, they include a variety of cognitive functions and styles of thinking and develop in the learning environment; and, the third subcategory, the workplace competencies, covers the motivation, personal qualities, interpersonal communication and self-management styles that are needed in different professions.

In turn, industry-specific competencies fall into two subcategories: industry-wide technical (which include knowledge, skills and abilities that serve as a kind of general competency framework and are necessary for the effective professional activity of engineers in industry, regardless of the industry, thus allowing a smooth transition of workers from one industry to another), and industry-sector functional competencies (industry competencies that cover the knowledge, skills and abilities of an engineer specific to a particular industry).

NHESs serve as the framework for higher education institutes to develop and update their courses. In order to see how NHES's expected learning outcomes are relevant to the students' expectations, we interviewed undergraduate students' (Electronics Engineering program). The Questionnaire (**Table 1**) was formulated through I-statements, where participants had to agree or disagree with 10 questions, based on the main concepts, presented by the NHES's learning outcomes.

Table 1

Undergraduate Engineering Students' Perceptions of Learning Outcomes in Academic Disciplines

	Questions	5	4	3	2	1
Q1	I know what knowledge lecturers expect me to gain by the end of their course.					
Q2	I know what skills lecturers expect me to develop by the end of their course.					
Q3	I know where to find the learning outcomes for the course I study.					
Q4	Documents that contain course learning outcomes are easily accessed.					
Q5	I understand how my knowledge and skills will be assessed throughout the course.					
Q6	I understand how the course content helps me to gain new knowledge and develop skills.					
Q7	I can track my progress throughout the course.					
Q8	I believe that the number of points, distributed per each course task, is balanced and reasonable.					
Q9	If I am aware of my learning outcomes at the beginning of the course, I better perform throughout the course.					
Q10	When I understand how course content and tasks are related to my learning outcomes, I better perform throughout the course.					

Note: Questionnaire: 1 – Strongly disagree; 2 – Disagree; 3 – Neither agree, nor disagree; 4 – Agree; 5 – Strongly agree

Fig 1. presents the percentages of the undergraduate students' perceptions of learning outcomes in the electronics engineering program.

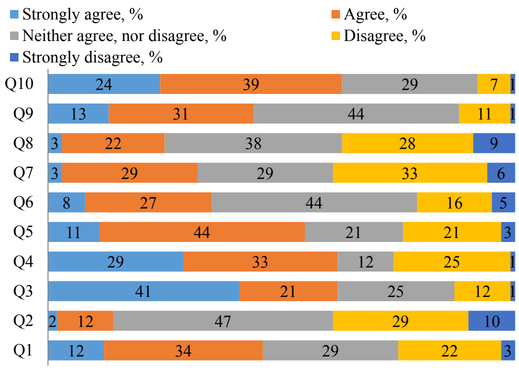

Fig. 1. Undergraduate Students' Perceptions of Learning Outcomes in Academic Disciplines (Electronics Engineering Program), n=67

At the first stage, we observed that with regard to the knowledge (Q1) that lecturers expect students to gain by the end of their course, almost a half of participants negatively responded to the question. The skills set questions (Q2) students were less likely to disagree. The interview also showed that 62 % (Q3–Q4) of participants know, where to find the learning outcomes for their courses and what documents to address. However, only 55 % of interviewees knew, how their knowledge and skills will be assessed throughout the course (Q5). Moreover, 21 % of students do not see the relevance between the subject content they study and the skills they acquire (Q6) and more than a third of participants are not able to track their progress (Q7) due to the pitfalls of assessment criteria, lecturers' ambiguity in explanations and reporting. Interestingly, only 25 % of participants agree that, points distributed per each course task, are balanced and reasonable (Q8) i. e. participants noted that the practical component should bring more points in order to eliminate the cases of cheating. In addition, 44 % support the idea of bringing much more attention to the expected learning outcomes at the beginning of the course (Q9) and almost 63 % agreed that understanding the relations between the course content and tasks would made their learning much

more beneficial (Q10). For instance, students would appreciate their lecturers to prepare the block diagrams or infographics in order to track those relations easier.

Overall, the questionnaire demonstrated that such aspects as course content organization, performance-based assessment criteria can be improved by lecturers in the short-term perspective.

The second stage (**Table 2**) demonstrated how NHES overall undergraduate outcomes can be identified by students in the undergraduate subjects. The EE NHES for undergraduate students was developed by the group of Ukrainian lecturers [15], and its 18 outcomes were transformed into can-do statements by the author and then translated into English.

Table 2

Undergraduate Students' Perceptions of Expected Learning Outcomes

Outcomes	Can-do statements	Yes	Not sure	No	Comments
1	2	3	4	5	6
O1	I can describe the principle of operation using scientific concepts, theories and methods, and test results when designing and applying electronics tools, devices and electronic systems.				
O2	I can apply knowledge and understanding of differential and integral calculus, algebra, functional analysis of real and complex variables, vectors and matrices, vector calculus, differential equations in ordinary and partial derivatives, Fourier transforms, statistical analysis, information theory, numerical methods for solving theoretical and applied problems of electronics.				
O3	I can find solutions to practical problems of electronics through application of relevant models and theories of electrodynamics, analytical mechanics, electromagnetism, statistical physics, and solid state physics.				
O4	I can evaluate the characteristics and parameters of electronic materials, understand the basics of solid-state electronics, electrical engineering, analogue and digital circuits, transformers and microprocessors.				
O5	I can use information and communication technologies, applied and specialized software products for solving tasks in design and setting of electronic systems, demonstrate the skills of programming, analysis as well as displaying measurement and control results.				
O6	I can apply experimental skills (knowledge of experimental methods and procedures for conducting experiments) to test hypotheses and study electronics phenomena, I am able to use standard equipment, plan, compose circuits; analyze, model and critically evaluate the results.				
O7	I can analyze sophisticated digital and analogue information and measurement systems with advanced computer and telecommunications network architecture, taking into account the specification of selected electronics and related technical documentation.				
O8	I can identify and specify mathematical models of technological objects while developing new complex electronic systems in a computer environment and when choosing the best solution.				
O9	I can design sophisticated real-time systems as well as data collection and processing tools in order to meet the specified media and software by using software for microcontroller-based embedded systems.				
O10	I can develop technical means for constructing and diagnosing the technical condition of electronic devices and systems, organize and carry out routine and unscheduled repair, debugging and reconfiguration of electronic equipment in accordance with current production requirements.				
O11	I can justify the regulatory framework for the introduction of electronic devices and systems; evaluate the benefits of engineering development, its environmental friendliness and safety; defend one's world views and beliefs within business or social activities.				
O12	I can use documentation, related to professional activity, using modern technologies and office equipment; use English, including special terminology, for communication with specialists, resources search as well as reading texts on technical and professional topics.				

Continuation of Table 2

1	2	3	4	5	6
O13	I can acquire new knowledge, apply advanced technologies and innovations, find new unconventional solutions and means of their implementation; meet the requirements regarding flexibility in overcoming obstacles and achieving goals, efficient timing, discipline, responsibility for my decisions and activities.				
O14	I can adhere to the norms of modern Ukrainian language for business and professional purposes.				
O15	I can demonstrate skills of working independently and in a team, leadership skills, organize work within limited time with a focus on professional responsibility.				
O16	I can apply theories of stochastic processes, methods of statistical data processing and analysis when solving professional tasks.				
O17	I can demonstrate experimental research skills, related to professional activity; improve measurement techniques; control the accuracy of the results obtained; systematize and analyse experimentally obtained data.				
O18	I can apply methods of mathematical modelling and electronic systems optimization for the development of automated and robotic production complexes.				

The three groups of answers i. e. *Yes/Not sure/No* allowed us obtain the following results: 67 % of participants answered positively, 29 % responded *Not sure* and 4 % chose the answer *No*. Participants commented that “the wording was so confusing that sometimes it was difficult to understand what I can do”; “I know that I can do that, but could not specify exactly the statement”; “not sure that I remember that staff” etc.

Broadly speaking, we can see that despite the well-developed structure and content of the EE NHES, in real life course developers must implement them, but seem to need more practice in order to let their student feel a performance focus of the EE NHES outcomes.

5. Discussion

The results confirm that professional development programs for lecturers and induction courses for students are an important component if successful in order to train EE course developers to adequately applying NHES outcomes in EE courses as well as make existing assessment criteria outcome-oriented.

These results match the recent research. Proceeding from the main objective of the socio-economic development of Ukraine until 2025, the results of the study of the necessity of human capital and the ability of scientific and pedagogical schools of Ukraine to carry out training of human capital has challenged the government to undertake a sequence of actions in order to ensure high-tech development of the country in the medium-term (by 2020) and long-term (by 2030) perspectives [16]. The Foresight discusses trends and challenges in educational systems for natural sciences and engineering education in secondary schools and higher education, and proposes steps towards improving the quality of education in Ukraine [16, p. 29–31].

Summing up the results, our attempt to identify the students’ perceptions of EE NHES through HELOs could be beneficial for the potential broader research in this field.

6. Conclusions

The growing role of electronics in all spheres of our life, the rapid production automation, transition to electronic means of data transmission and processing stimulate the need for training highly-qualified specialists in many fields, namely in electronics engineering. Thus, higher education needs to ensure that the development of corresponding key competencies of electronics engineers, professional thinking, ability to make decisions and implement them in their professional activities, as well as awareness of the role and ability for continuous professional development, play a paramount role in designing university courses in this field.

EE NHES attempted to frame the outcomes that make EE programs more competitive at the job market. However, further research points out the need to use larger samples of participants, to evaluate EE NHES for graduate students and outline the vision for potential professional development programs for lecturers.

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