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ENVIRONMENTAL AWARENESS OF CIVIL ENGINEERS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT OF SOCIETY

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Abstract

In the context of the man-made burden on the natural environment, the issues of developing civil engineering students' environmental awareness are important and particularly relevant to low environmental security countries, which include Ukraine. The authors emphasize the need for broad implementation of the Concept of Sustainable Development in professional training of civil engineering students, determine the level of their environmental awareness, compare the levels of formation of environmental awareness components, and pursue to identify effective ways to environmentalize engineering training. The study involved the students of Donbas National Academy of Civil Engineering and Architecture. The authors selected the semi-structured questionnaire method combining rating, Likert and importance scales, alternative and unstructured questions, as well as elements of the Azapagic and the Naturafil techniques. The results did not prove the formation level of the civil engineering students' environmental awareness to be unsatisfactory. It was also found that the civil engineering students have steady environmental beliefs and are willing to comply with environmental norms in their activities. This fact brought the authors to the conclusion that the current practice of higher technical education in Ukraine takes account of sustainable development. The level of the civil engineering students' environmental knowledge was also determined as sufficient, while their environmental activity and environmental management skills were seen as low. According to the authors, the use of integrated and practice-oriented approaches to teaching professional subjects and the introduction of environmental topics into general education subjects will contribute to strengthened environmentalization of professional training of civil engineers.
Keywords: *civil engineer, environmental awareness, higher school, sustainable development, technical education*

Introduction

The rapid scientific and technical advances of the humanity have caused the global problems: famine and poverty of a part of the world population, moral degradation, growing frequency of regional and interethnic conflicts, terrorism, and, most importantly, environmental deterioration. These challenges prompted the progressive world community in the 21st century to change approaches to addressing common problems: in the late 1970s the International Union for Conservation of Nature developed the *World Conservation Strategy*, and the 1972 United Nations Conference on the Environment in Stockholm initiated *the World Concept of Sustainable Development*, which is highlighted in a number of international documents, namely,

Agenda 21, the United Nations Global Compact, *the Millennium Development Goals, Towards a Sustainable Europe by 2030, Johannesburg Declaration on Sustainable Development* and the like.

Research Problem

Sustainable development is the process of developing a state through coordination and harmonization of social, economic and environment dimensions to fill the needs of the contemporary and future generations (European Commission, 2019; Ministry of Economic Development and Trade of Ukraine, 2017). However, the term 'sustainability' is most associated with the issues relating to the environment and is interpreted as such a quality of human practical activities that can be performed for a lengthy period in the future, since the benefits it gives exceed the costs it entails (Boca & Saraçh, 2019; Lönngren, 2019; Miñano Rubio et al., 2019). In the international documents on the issues of sustainable development, special attention is given to the environmental awareness of citizens, conceptual approaches to preserving the biosphere and civilization (European Commission, 2019; Ministry of Economic Development and Trade of Ukraine, 2017).

This raises the questions addressed to university engineering education as an institution that trains professionals who will urbanize the natural environment in the future. Researchers point out that the main benefit that the society obtains from training prospective civil engineers is the creation of a corps of professionals who are able to develop useful things, and there is a direct link between the quality of their education at university and their further professional activities. For this reason, technical universities, like no other education institutions, are to provide for environmental education and train engineers to develop the so-called 'green society' (Boca & Saraçh, 2019; Edström et al., 2020; Lönngren, 2019). The World Federation of Engineering Organizations also emphasizes that training prospective civil engineers should be based on the principles of sustainable development, one of the key tasks of which is the preservation and restoration of natural ecosystems and their abilities to renew (Miñano Rubio et al., 2019).

In the scientific framework, the provision of education for sustainable development (ESD) in the field of engineering, particularly its environmentalization, is seen as a relevant issue and is considered from theoretical and practical aspects: education in environment, education for environment, education about environment, education to environment (Boca & Saraçh, 2019). One of the efficiency marks for different ways of environmentalizing the professional training of prospective engineers is the level of development of their environmental awareness.

Theoretical Framework

The term 'environmental awareness' has different definitions. Thus, Deriabo and Yasvin (1996) note that environmental awareness is a complex of a person's environmental understandings, the existing attitude to the nature, as well as appropriate strategies and technologies to interact with it. Skrebets (1998) defined environmental awareness as 'the highest level of psychological reflection of the natural and artificial environment, one's inner world, the reflexion concerning the place and the role of a person in the biological, physical, and chemical worlds, as well as the self-regulation of this reflexion'. Mudrak (2017) characterized the environment-oriented awareness as an integral feature of the environment- oriented personality of an engineer, whereas Ivanov et al. (2016) assert that it is the main indicator of the environmentalization efficiency in an engineering higher education institution.

Having summarized the existing approaches to defining the term 'environmental awareness', the authors of the paper concluded that most of them interpret this prospective

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engineer's phenomenon as a unity of three components: environmental knowledge, environmental beliefs and environmental conduct. In our study, 'environmental awareness' is thus regarded as *an active environmental protection activity of a prospective civil engineer in everyday and professional life, in the process of which his/her system of environmental knowledge and willingness to take responsibility for the state of the environment comprehensively interact.*

Research Focus

Researchers from different countries conduct empirical studies of the level of the development of prospective engineers' environmental awareness by analyzing its structural components and defining their correlation.

Thus, using the Naturafil technique, Ivanov et al. (2016) carried out the complex monitoring on the environmental awareness level of metallurgy students in Ukraine. The scientists found out that the students define nature as a secondary value, most of the students have the medium intensity level of attitude to nature, and their general level of environmental awareness is between 56% and 67% and is exposed to the fluctuations of informational and emotional scales from the 1st to the 5th years of study. According to the researchers' conclusions, the practical component has the highest level of development (52% for undergraduate-level students and 60% for graduate-level students), whereas the cognitive component has the lowest level of development (48% for undergraduate students and 53% for graduate (Master's degree) students).

Azapagic et al. (2005) measured the knowledge level of engineering students in different world regions using the author's questionnaire and found out that there was a discrepancy between cognitive and axiological components of the students' environmental awareness: the level of recognizing the importance of sustainable development is between 85% and 87%, the level of environmental knowledge is between 74% and 76%. Summing up the results gained allowed the authors to conclude that the level of environmental awareness development is medium and there is no significant difference between the undergraduate and graduate students – maximum 0.3%.

The similar studies (based on the questionnaire by Azapagic et al. (2005)) conducted by Nicolaou and Conlon (2012) in Ireland, Murzia et al. (2019) in Australia prove that most respondents are not aware of the complexity of the concept, do not possess sufficient knowledge about the laws and social aspects of sustainable development, though they are concerned about environmental protection. The environmental knowledge of prospective engineers was found as insufficient, and their environmental awareness and moral considerations were at the medium level of development.

Boca and Saraçh (2019) pointed at the discrepancy between environmental awareness and the absence of involving prospective engineers in Romania in practical environmental protection activities. The scientists found out that Romanian students commend environmental behavior, especially in volunteering activities, they have an ecological approach regarding the environment, but they dislike participating in direct activities, which means that the activity-based component of their awareness is less developed than beliefs and knowledge.

In the survey conducted by Mudrak (2017), it was revealed that engineering students in Russia have the following indicators: environmental knowledge (65%), environmental liability (63%), environment-oriented activities (45%). The researcher respectively found the level of the development of the cognitive and axiological components of their environmental competency as sufficient, but the level of the activity-based component was insufficient.

Heyl et al. (2013) studied the influence that the year of study of civil engineering students in Chile has on their attitude to the environment and their pro-environmental behavior. The researchers found out that on average both undergraduate and graduate students had a

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positive attitude to the environment (75%–80%), which was also revealed at the behavioral level (62%–65%). The students enrolled in the environment-orientated academic courses had better results at both cognitive and behavioral levels, while the level of the students' efforts regarding environment protection activities had an indicator of 43.3%.

Basing on the review of the research results, the authors summarized the global trends in the development of engineering students' environmental:

- environmental awareness of prospective engineers is at the general level of 50%–70%, which, in our opinion, significantly depends on the level of the country's development;

- the cognitive component of prospective engineers' environmental awareness is mostly diagnosed to be at the highest level of development, while the behavioral component is at the lowest.

Research Aim and Research Questions

The objectives of the study are: 1) to diagnose and compare the levels of development of environmental knowledge, environmental beliefs, and environmental conduct of prospective civil engineers in Ukraine (by the example of the Donbas National Academy of Civil Engineering and Architecture); 2) to determine the general level of formation of civil engineers' environmental awareness and to outline the main ways of its development in the process of professional training.

The research questions are the following: at what level of development is the environmental awareness of prospective civil engineers in Ukraine in the context of the implementation of the sustainable development concept? How do the levels of their environmental knowledge, environmental beliefs, and environmental conduct correlate? What are the ways to environmentalize professional training in higher technical schools?

Research Methodology

General Background

The study was conducted at the Donbas National Academy of Civil Engineering and Architecture (DonNACEA) (Kramatorsk, Donetsk region, Ukraine) during the academic year of 2019–2020 with the purpose to determine the overall level of environmental awareness of prospective civil engineers and to identify ways to enhance the environmentalization of their training in accordance with the requirements of the Concept of Sustainable Development. Students of level I (undergraduate) and level II (graduate) of higher education participated in the research. The empirical study was aimed at a separate diagnostic of the three components of environmental consciousness: environmental knowledge, environmental beliefs, and environmental conduct. Further, the average indicator was determined, which was to generalize the level of development of prospective civil engineers' environmental awareness in Ukraine.

Sample

For the empirical study to be conducted, 440 undergraduate and graduate students of the Donbas National Academy of Civil Engineering and Architecture (DonNACEA) were sampled. The numerical composition of the respondents was formed on the basis of informing the entire student body of DonNACEA about the purpose and objectives of the study. Then those who were interested in the study and agreed to participate in it signed an informed consent statement. During the sampling, the respondents' results were distinguished between level I (academic years 1 – 4) and level II (academic year 5–6) of higher education. Accordingly, the sample

included 230 undergraduate students and 210 graduate students (master's degree), which enabled us to determine not only the positive and negative aspects of environmental awareness of the prospective civil engineers but also to track the dynamics patterns of its development during their studies at a higher technical education institution.

Instrument and Procedures

For conducting the empirical research, the method of semi-structural questionnaire was chosen. The questionnaire contained three parts: the introductory one, which included the explanation of the questionnaire aim; requisites (respondent's gender, year of study, date and time of answering); the main part including questions for a respondent. The main part contained such question types as rating scale, Likert scale, scale of importance, alternative questions, and non-structured questions. Two parts of technique of Azapagic et al. (2005) and some elements of the 'Naturafil' technique (Deriabo & Yasvin, 1995; Ivanov et al., 2016) were used in the questionnaire.

The technique of Azapagic et al. (2005) includes two parts of the questionnaire. The first part is aimed at measuring the scope and thematic diversity of engineering students' knowledge about the environment and sustainable development and consists of such thematic blocks: environmental issues; environmental legislation, policies and regulations, etc. The second part is aimed at determining the level of students' interest in sustainable development and sustainable use of nature, recognition of important components of sustainable development at personal and professional levels. As a measuring tool, the authors used the Likert scale in the first part of the questionnaire (choosing the degree of awareness of a particular environmental topic, choosing grades from 1 to 5 for the given statements), in the second part – the scale of importance (assessing the importance of sustainable development for different categories of people and environmental standards for various fields of environmental management and human activities).

The 'Naturafil' technique (Deriabo & Yasvin, 1995; Ivanov et al., 2016) was developed to diagnose the intensity of personal attitudes toward nature by using unstructured questions. The measurement is carried out according to 3 main scales: perceptual-affective scale (diagnostic of the degree of changes in the system of a person's affectively colored 'sample' having aesthetic, ethical and vital character in relation to nature); practical scale (diagnostic of practical activities with objects of nature, arising from the attitude to it, which are manifested in the commitment and willingness for practical interaction with natural objects); behavioral scale (diagnostic of changes in a person's conduct arising from the attitude to nature, which is manifested in a person's activism to change the environment in accordance with this attitude).

For the study, the authors developed a semi-structured questionnaire, consisting of three blocks aimed at diagnosing the level of development of each of the three components of environmental awareness: environmental knowledge (block K), environmental beliefs (block B) and environmental conduct (block C).

To determine the level of development of the DonNACEA students' environmental knowledge, the first part of the technique of Azapagic et al. was adapted and used (2005). When diagnosing the scope and thematic diversity of the prospective civil engineers' environmental knowledge, the questions of block K of the questionnaire were used: K. 1 – environmental issues (15); K. 2 – environmental legislation, policies and regulations (9); K. 3 – environmental methods, technologies and approaches (12); K. 4 – 'The Concept of Sustainable Development' (10) (e.g., Figure 1).

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Figure 1
Example of Block K Questions of the Questionnaire

K.1 Assess the level of your knowledge in the topics:

K.1.1 Environment	Never heard of	Heard of but cannot explain	Have some knowledge	Know a lot
Acid rain				
Air pollution				
Biodiversity				

Measuring the level of development of environmental beliefs of the civil engineering students was carried out in block B questions. Component B. 1 was aimed at determining the beliefs of the prospective civil engineers about the importance of sustainable development of society (5), and B. 2 – about the importance of environmental norms for various fields of human activity (12). To do this, the second part of the technique of Azapagic et al. (2005) was utilized, which was provided for the use of a scale of importance (Figure 2).

Figure 2
Example of Block B Questions of the Questionnaire

B.1 How do you assess the importance of sustainable development for the following categories of persons:

Categories of persons	Not important	Maybe important	Important	Very important
Ordinary persons				
Engineers				
Country as a whole				

The level of the development of environmental conduct in questionnaire part C. 1 was checked by using an alternative scale and the elements of the 'Naturafil' technique (Deriabo & Yasvin, 1995; Ivanov et al., 2016), and in part C. 2 – by using unstructured questions. C. 1 consisted of 10 statements concerning the practice of positive environmental conduct common to students in everyday life. The respondents had to confirm or deny those statements. Part C. 2 used unstructured open-end questions that determined the means of practical implementation of the environmental component in the professional training of prospective civil engineers (C. 2.1), their practice of participating in 'green construction' projects (C. 2.2) and ways to comply with environmental standards they use in their own construction projects (C. 2.3).

Data Analysis

The quantitative results of all parts of the semi-structured questionnaire were put into an Excel spreadsheet and content analysis of the responses and summarizing of the results was performed. In block K for the quantitative calculation of the obtained data was used a system of points on a 1–4 scale, where each answer indicated the following number of points: 'Never heard of' – 1 point; 'Heard of but I cannot explain' – 2 points; 'Have some knowledge' – 3

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points, 'Know a lot' – 4 points. The quantitative calculation of the obtained data for block B was performed similarly to block K, and each answer indicated the following number of points: 'not important' – 1 point; 'perhaps important' – 2 points; 'important' – 3 points, 'very important' – 4 points. For each of the parts of blocks K and B, the results were calculated as follows: the arithmetic mean was determined by the formula $\mu = (x_1 + x_2 + x_n)/n$ for cumulative points obtained by each respondent; further on, for these values of all students of a correspondent level the arithmetic mean was determined for each of the parts of the blocks: K.1, K.2, K 3, K.4, B.1, B.2; then the arithmetic mean for all students of a certain level for the whole block was calculated. According to the summary table of arithmetic means of each respondent for each part of blocks K and B, the standard deviation was calculated by the formula $\sigma = \sqrt{[(\sum(x-x)2)/n-1]}$. Thus, within the scale 1–4, the average level of environmental knowledge (beliefs) of students was determined. During the analysis of the results, the percentages were calculated basing on the fact that 4 equals 100%. In part C.1, the number of positive responses to each of the given statements (0–10) was determined and later translated into a percentage format (for L1 230 = 100%, for L2 210 = 100%). In part C. 2, a quantitative analysis of the results was first conducted by determining the number of respondents who provided answers to the questions and then this number was translated into a percentage format by the identical relation. At a later stage, the content analysis of the answers and the sum-up of the results were employed.

Having determined the quantitative indicators of the level of development of each of the components of the civile engineering students' environmental awareness, the authors conducted a comparative analysis using the distribution by levels, where 80%–100% corresponded to a high level; 50%–79% – a sufficient level; 20%–49% – to a satisfactory level; 0%–19% – unsatisfactory level. On this basis, the overall indicator of the level of development of prospective civil engineers' environmental awareness was determined.

Research Results

To determine the level of the development of environmental knowledge of the DonNACEA civil engineering students' environmental awareness, they were asked to determine the degree of their own awareness of environmental issues presented in block K of the questionnaire. The summarized quantitative results of the analysis of the responses of the respondents of levels I and II of higher education by parts of block K. 1 – K. 4 are presented in Table 1.

Table 1
The Results of Diagnosing the Cognitive Component of the Prospective Civil Engineers' Environmental Awareness (2020)

Questionnaire parts	Average score (μ)	
	level I of HE	level II of HE
K. 1 'Environment'	2.7	2.8
K. 2 'Environmental Legislation'	1.7	1.9
K. 3 'Environmental Tools, Techniques and Approaches'	2.5	2.6
K. 4 'The Concept of Sustainable Development'	2.1	2.6
σ	0.4	0.4
μ	**2.3**	**2.5**

As the data presented reveal, the civil engineering students have mastered the topic 'Environment' the best, whereas the least mastered topic is 'Environmental legislation'. The topics 'Environmental Tools, Techniques and Approaches' and 'The Concept of Sustainable Development' are at the medium level – 2.1 – 2.6 points. In answers to the questions for topics K. 1 – K. 3 there is no essential difference in average total points for both undergraduate and graduate students, as the fluctuation of 0.1 – 0.2 points is not statistically significant. Regarding topic K. 4, this fluctuation is more significant and concerns graduate studies, which means that the graduate students' level of knowledge about the Concept of Sustainable Development is above average by 0.5 point.

The qualitative analysis of the respondents' answers has shown that there are environmental topics which students are more knowledgeable about: air and water pollution, deforestation, global warming, depletion of natural resources (K. 1); the Law of Ukraine 'On Environmental Impact Assessment'; the Land Code of Ukraine on Land Fund Defects (K. 2); waste minimization, renewable energy sources, sustainable building or 'green building', eco-design, environmentally sound technologies (K. 3); population growth, social responsibility, balanced patterns of consumption and production (K. 4). The topics on which students have almost no knowledge were also pointed out: photochemical smog, salinity (K. 1); ISO 14001, EU EMAS (K. 2); urban ecology, life cycle assessment, eco-labeling (K. 3); the attitude of the engineering community to sustainable development, approaches to sustainable development, components of sustainable development (K. 4).

The difference in average points gained by the students of level I and level II of higher education also deserves attention. Thus, in part K. 1 there is virtually no difference and at times the undergraduate students' average points are higher than those of the graduate ones. In parts K. 2 – K. 4 the increase vector is unexceptionally directed to the graduate students and the difference is between 0.1 and 0.7 points. The biggest difference is observed in part K. 4 for the following topics: 'Sustainable development: definition, vision, goals' – 0.7 point; 'Social responsibility' – 0.6 point; 'The consumer pays principle' and 'The attitude of the engineering community to sustainable development' – 0.5 point each.

The questionnaire block B, which consisted of parts B. 1 and B. 2, was dedicated to measuring the prospective civil engineers' *environmental beliefs*. The purpose of part B. 1 was to determine the level of the students' awareness and beliefs in the field of sustainable development of society and compliance with environmental requirements. Thus, the DonNACEA students of levels I and II of higher education were asked to assess the importance of the following: B. 1 – sustainable development for different categories of persons; B. 2 – observance of environmental norms in various human activities and environmental management. The results obtained are presented in Table 2.

Table 2

Results of Diagnosing the Environmental Beliefs of the Prospective Civil Engineers (2020)

Questionnaire parts	Average score (μ)	
	level I of HE	level II of HE
B. 1 Sustainable development	3.1	3.2
B. 2 Environmental norms	3.6	3.6
σ	0.4	0.3
μ	3.4	3.4

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The presented data show that the students' beliefs about the importance of sustainable development have in general lower numerical expression than their environmental beliefs concerning the importance to observe environmental norms in various fields of human activity by 0.4 and 0.5 points according to the levels of higher education. While determining the importance of sustainable development for different categories of persons, the respondents of both levels of higher education gave the highest point for future generations (3.2 points – undergraduate students, 3.6 points – graduate students). The lowest point was given to ordinary citizens (2.9 points – undergraduate students, 2.6 points – graduate students) and engineers (2.9 points – undergraduate students, 3.0 points – graduate students).

Thermal energy is considered by civil engineering students to be the most dangerous field of human activities in terms of nature conservation: (3.9 points – undergraduate students, 4.0 points – graduate students). The students of both levels of higher education see the following areas as principal ones by the degree of hazard and the importance of compliance with environmental norms: transport (3.9 points – undergraduate students, 3.9 points – graduate students); military activity (3.8 points – undergraduate students, 3.9 points – graduate students); civil engineering (3.8 points – undergraduate students, 3.8 points – graduate students). Among the areas where compliance with environmental regulations is less important, the students of both levels of higher education indicated cultural activities (2.7 undergraduate students, 2.8 graduate students) and scientific activities (2.9 undergraduate students, 2.4 B. – graduate students).

Diagnostic of the *behavioral component* of environmental awareness in part C. 1 of the questionnaire summarized the practice of environmental behavior of students in everyday life through 10 statements that illustrated the practice of pro-environmental conduct.
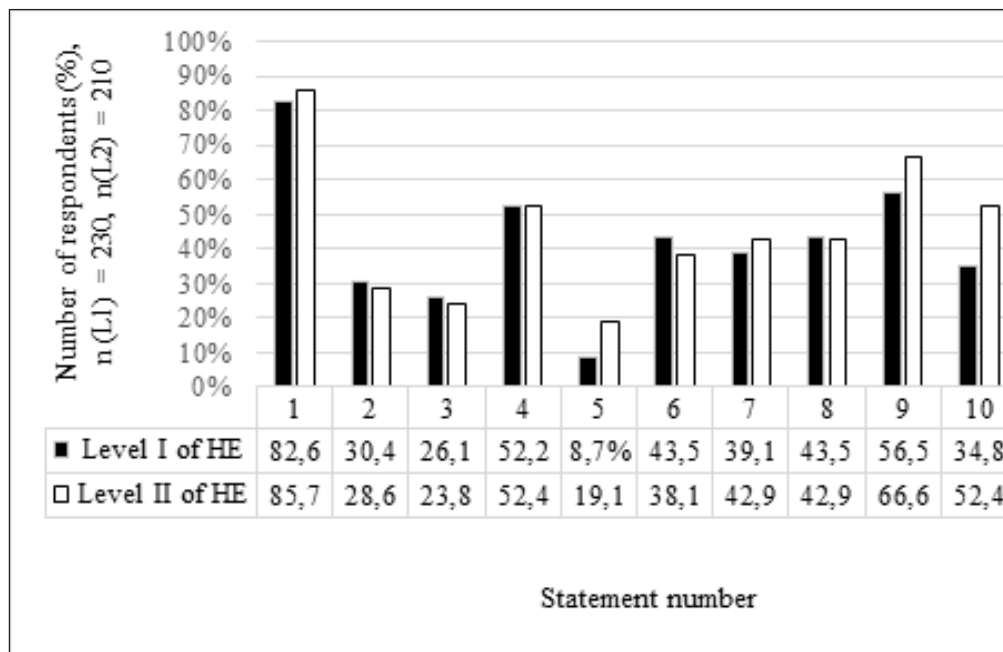
The calculated number of positive responses per every student showed 46.7% and 45.2% as the level of development of the students' environmental behavior for levels I and II of higher education. Moreover, this level of students of level I of higher education is 1.5% higher than that of the graduate students, in contrast to the respondents' environmental knowledge and beliefs.

The quantitative results of the application of the alternative scale by the statement numbers are shown in Figure 3. The vertical axis shows the number of students who marked 'yes' regarding the 10 statements indicated on the horizontal axis. Content of statements:

1. I save water when washing and taking showers
2. I refuse plastic bags at home
3. I buy coffee (tea) from vending machines (kiosks) into my own cup
4. I prefer environmentally friendly transport (bicycle, hoverboard, trolleybus, etc.)
5. I am engaged in eco-volunteering (I take part in environmental actions)
6. I never break branches on bushes or trees
7. I try to buy food products and drinks in packaging that is not harmful to the environment
8. When shopping, I am guided by the following principle: first comes environmental friendliness, and only then – the price
9. I clean up litter left by someone on a forest glade or near my house
10. I do the waste-sorting at home

Figure 3

Number of Respondents (%), who Gave the Positive Response to the Statements of Questionnaire Part C. 1 (2020)
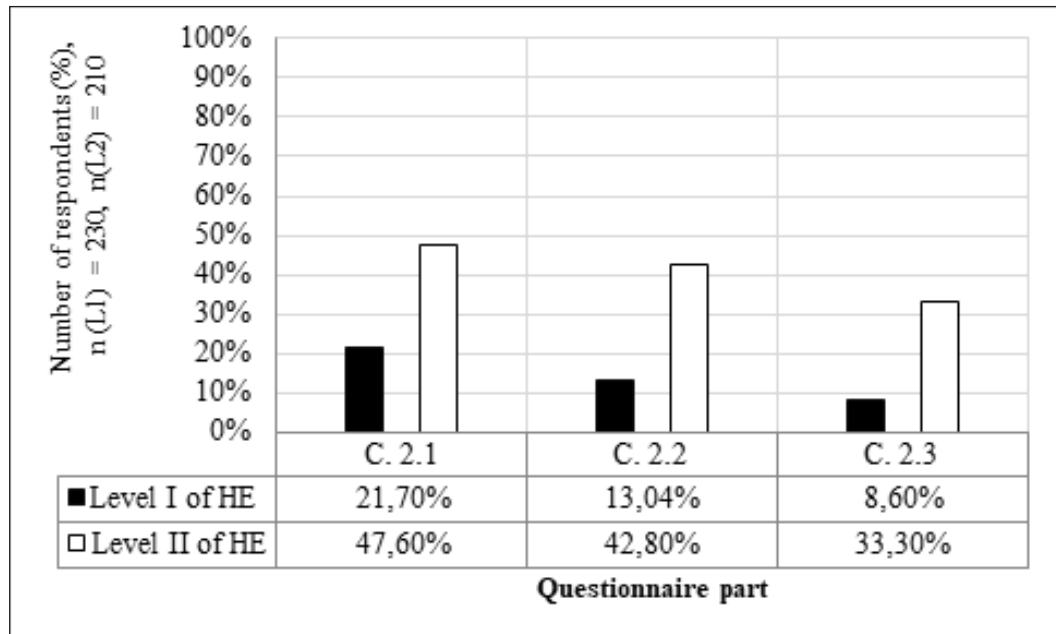

The diagram shows that the practice of pro-environmental behavior is the same for undergraduate and graduate students because the number of people who marked 'yes' for the given statements is the same or different in 1–2 respondents almost for all items. Thus, the decrease vector in most items (items 1 – 4, 6, 8) is directed towards the students of level I of higher education. In general, students of both levels of higher education gave most number of positive responses in items 1, 9, 4; the average values were taken by statements 6, 7, 8; the lowest number of positive responses was observed in statements 2, 3.

Item 10 showed difference between the students of level I and level II of higher education: among the undergraduate students, 80 out of 230 respondents (34.7%) do so, and among the graduate students – 110 out of 210 respondents (52.3%). A similar difference was observed in item 5: 20 undergraduate students (8.7%) and 40 graduate students (19%).

Part C. 2 provided for the students to answer the following unstructured questions: C. 2.1 'During classes in which subjects do you discuss ways to comply with environmental norms in construction? What are these ways?'; C. 2.2 'Have you been engaged in green construction projects? If so, in which ones? If not, would you like to take part and in which ones?'; C. 2.3 'Give examples of allowing for environmental aspects in your own construction project.' The quantitative results on the responses provided for both levels of higher education are presented in Figure 4.

Figure 4
Number of Respondents (%), who Gave the Answers to the Questions of Part C. 2 (2020)

The diagram shows that in this part of the questionnaire there is a significant difference between the results of the students of level I and level II of higher education. To open-end question C. 2.1 the students of level I of higher education mostly did not provide a complete answer, as they only mentioned the names of some subjects (Chemistry, Engineering Geodesy), the majority of those who provided a complete answer to the question did not indicate the methods they had mastered to comply with environmental norms in construction. Thus, the students of the 1st and the 2nd years almost 100% did not answer this question, having written 'do not know'. The students of the 3rd and the 4th years for the most part provided answers, but those were not complete. Regarding participation in 'green construction' projects (C. 2.2), the majority of the respondents of level I of higher education stated that they had never participated in such activities but would definitely take part if there was such an opportunity (60.8%). It is to be said, that only 30 students of the 3rd and the 4th years stated that they had the experience of such participation and they wanted to carry on. Unfortunately, 39.2% of the undergraduate students are reluctant to participate in such projects. Only 20 undergraduate students provided the answer to C. 2.3, most of them said that they did not have such projects yet, and therefore they could not give examples of taking environmental aspects into account in their own construction project.

In the answers the graduate students gave to the open-end question C. 2.1 they provided the names of subjects (fundamentals of construction industry, fundamentals of ecology, environmental impact assessment', construction materials science, 'architecture of buildings and structures, etc.) and methods to comply with environmental norms in construction (reduction of harmful emissions into the atmosphere, use of environmentally friendly materials, waste disposal, environmental inspection, etc.), which were discussed during the classes. 42.9% of the respondents gave incomplete answers, mentioning only the names of subjects, 9.5% wrote 'I do not remember', 'hard to answer', 'I do not know'. When asked about the experience of participating in 'green construction' projects (C. 2.2), 90 respondents had such experience and specified the names of projects, but 85.7% expressed their wish to participate in them.

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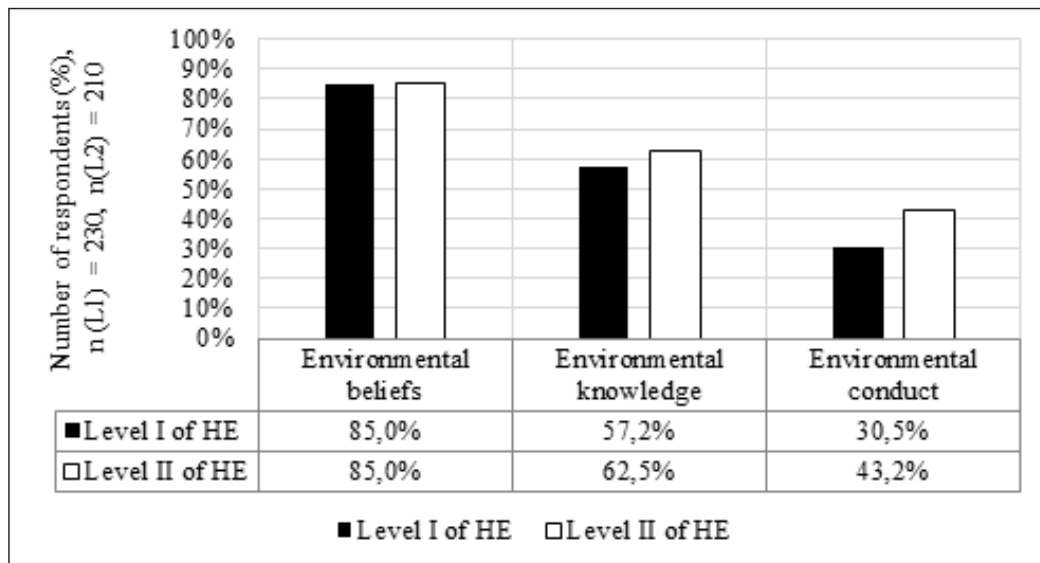OF EDUCATION
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Answering question C. 2.3, the respondents noted that, when developing construction projects, the following environmental aspects have to be accounted for: renewable energy sources, environmentally friendly building materials, the use of recovered waste materials, building environmental impact assessment and the like.

In summary, the practice of positive environmental conduct in everyday life (C. 1) for the undergraduate students takes 46.7%, for the graduate students 45.2%, while for professional activities (C. 2) this figure is 14.4% for undergraduate students and 41.2% for the graduate ones. The difference between the practice of compliance with environmental norms in their own professional activities between the undergraduate and graduate students is as follows: C. 2.1 – 36.3%, C. 2.2 – 17.6%, C. 2.3 – 59.2%. Such considerable divergence between the levels of higher education was found only in questionnaire part C. 2, whereas at other levels it either does not exist or is between 1.5% and 5%.

The comparative analysis of the levels of development of the components of the civil engineering students' environmental awareness is presented in Figure 5. The average level of environmental awareness for undergraduate students is 57.6% and for graduate students is 63.6%.

Figure 5

Comparative Analysis of the Levels of the Development of Prospective Civil Engineers' Environmental Awareness Components (%) (2020)

	Environmental beliefs	Environmental knowledge	Environmental conduct
■ Level I of HE	85,0%	57,2%	30,5%
□ Level II of HE	85,0%	62,5%	43,2%

■ Level I of HE   □ Level II of HE

Discussion

Summarizing the quantitative results of the analysis of the respondents' answers in block K reveals that the level of development of the cognitive component of the prospective civil engineers' environmental awareness is at a *sufficient* level of 2.3 and 2.5 points (57.5% and 62.5%). The scope of environmental knowledge of graduate students is higher by 5%. Regarding the qualitative analysis of the respondents' answers to topics K. 1 – K. 4, it should be noted that the topics that have the highest points (better known to civil engineering students) are included in a variety of ways in study programs for prospective civil engineers in DonNACEA and have a satisfactory scope and representation in all thematic parts. Accordingly, the topics with the lowest points (civil engineering students are much less knowledgeable of them) are little or not at all studied in the curricula of general education and professional training of

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prospective civil engineers and they are to be focused on by developers of study programs when reviewing and improving their content. The topics related to environmental legislation and policy require special attention.

Almost no difference in the average point between the students of levels I and II of higher education on certain topics in part K. is attributive to the presence of more well-known topics, while the other parts require a special study of environmental issues in the cycle of professional subjects. The biggest discrepancy in part K. 4, in our opinion, is due to the fact that the topics in this part are close to the future professional activities of civil engineering students and are the most highlighted by the professional subjects during studies at the Academy. This is viewed as a prognostic feature in the context of the implementation of the Concept of Sustainable Development in higher engineering education in Ukraine.

The data obtained from measuring the prospective civil engineers' environmental beliefs (block B), show that in the minds of students, environmental norms are not an integral part of sustainable development of society, they separate these concepts, putting more economic and social components in the concept of sustainable development. The highest point given by the respondents of both levels of higher education to the importance of sustainable development for future generations means that they understand the fundamental nature and global goal of sustainable development; the lowest point given for ordinary citizens illustrates the students' lack of awareness of their own roles as citizens or professionals in this global process. This confirms and complements the previous conclusion that teachers should give special attention not only to the theory of sustainable development but also to motivating prospective civil engineers to become more aware of their role in implementing the Concept of Sustainable Development.

Ascribing their future profession to the four most hazardous to nature indicates that the students of both levels of higher education have environmental beliefs, which are the first step towards the implementation of environmental behavior in their professional activities. The fact that the students of both levels of higher education defined cultural and scientific activities as fields where compliance with environmental norms is less important shows that in all years of study civil engineers have their own beliefs about the importance of environmental standards in various areas of human activity, which in general matches the reality (the fields of scientific and cultural activity do not belong to the main areas of environmental policymaking). The calculation of the generalized average point (3.4 points) for B. 1 part allows us to determine the level of development of prospective civil engineers' environmental beliefs as high (85%).

Diagnostic of environmental conduct (block C. 1) showed that the practice of pro-environmental behavior for undergraduate and graduate students is the same. However, items 5 ('I am engaged in eco-volunteering (I take part in environmental actions)') and 10 ('I do the waste-sorting at home') contain differences between students of levels I and II of higher education, which is, in our view, based only on personality factors, since the students who demonstrated an active environmental attitude in these questionnaire items generally have a higher level of environmental behavior than others.

The answer 'I do not know' or partial answers provided by the students of level I of higher education to the open-end question C. 2.1 'During classes in which subjects do you discuss ways to comply with environmental norms in construction? What are these ways?' are they explained to the fact that the curriculum of the first years of training civil engineers is dominated by general education subjects.

Wide disparities in the indicators in block C with the undergraduate students between positive environmental behavior in everyday life and in professional activities is attributive to a lower level of professional knowledge and skills, and with the graduate students, the level of development of the activity-based component of their environmental awareness is approximately similar for everyday and professional activities.

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A significant discrepancy in the practice of observing environmental norms in their own professional activities between undergraduate and graduate students in the questionnaire part C. 2 means that in the practice of professional activities the process of studying at the Academy has the most effect and the students of level II of higher education show much greater progress compared to the undergraduate students. The general indicator of the level of development of the activity-based component by levels of higher education (30.5% for undergraduate students and 43.2% for graduate students) corresponds to a *satisfactory* level.

Comparing the levels of development of civil engineering students' environmental awareness allows to conclude that the highest level of development is characteristic of environmental beliefs, which means that the Academy students of different years of study have a conscious attitude towards observing environmental norms in their own conduct and obtaining additional environmental knowledge. Although the level of development of environmental knowledge was determined to be sufficient, there are critical gaps in the prospective civil engineering specialists' knowledge, which should be taken into account when adjusting study programs. Finally, environmental conduct, which is the basis of environmental awareness and demonstrates the result of its formation, is at the lowest level, which is defined as satisfactory. Finally, environmental behavior, which lies at the core of environmental awareness and demonstrates the result of its formation, is at the lowest level, which is still determined as satisfactory.

The general level of the undergraduate students' environmental awareness is 57.6%, and for the graduate students, it is 63.6%, which is an indicator of a sufficient level of development. This development level of the civil engineering students' environmental awareness in DonNACEA (Ukraine) is similar to the results emanating from studies conducted by Edström et al. (2020), Miñano Rubio et al. (2019), Chau (2007), Mudrak (2017), Poleshchuk et al. (2015), Pubule et al. (2019), Lambrechts et al. (2019), Maslennikova and Gibadulina (2019), Gray et al. (2019).

The findings of our study on the incompleteness of environmental knowledge were similar for Ukrainian civil engineering students and students from other countries: legislation for the sustainable development, its environmental and social aspects; environmental legislation, policies and norms; salinity, photochemical smog; industrial ecology; components of sustainable development (economy, society and environment). The same conclusions were reached by Mukhtar et al. (2019), Azapagic et al. (2005), Nicolaou and Conlon (2012), Murzi et al. (2019).

The study found that there was no significant difference observed between the scope of environmental knowledge of the undergraduate and graduate civil engineering students, which is consistent with the findings obtained by Boca and Saraçh, (2019), Mudrak (2017), Mukhtar et al. (2019), Heyl et al. (2013), Azapagic et al. (2005), Nicolaou and Conlon (2012), Murzi et al. (2019) and others. However, there is a discrepancy between the quantitative data obtained by Azapagic et al. (2005), whose research showed the maximum difference of 0.3%, and our findings proved to have 6% difference. It is considered that the difference is attributive to the lapse of time between the studies: since the early 21st century, higher education in most world countries has gained the certain practice of the environmentalization of engineering training that increases the level of environmental awareness in the course of study at technical universities.

During the study of the levels of development of the prospective civil engineers' environmental awareness components, it was found that the environmental behavior was the least developed. Similar conclusions were made by Boca and Saraçh (2019), Mudrak et al. (2019). However, there is a discussion between the results of our study and the findings made by Ivanov et al. (2016). The researchers noted that metallurgy students in Ukraine have the highest level of development of the practical aspect of their environmental awareness, while the cognitive and emotional components being at the lowest level.

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Conclusions and Implications

The construction industry has a major impact on the environment through building materials, energy, water and other resources, disrupting the environmental balance. The construction process also has a negative impact on the environment and facilities through noise emission, vibration, waste incineration, groundwater and soil contamination in particular. Ukraine is a country with a low level of environmental security so in the present-day context of the man-made burden on the environment the issues of developing prospective civil engineers' environmental awareness during their training are considered to be extremely relevant, though still understudied.

According to our study findings, the level of development of environmental conduct of the students of level I of higher education is higher than that of the graduate students, in contrast to environmental knowledge and beliefs. In our opinion, this indicates that the implementation of the Concept of Sustainable Development, including the formation of young people's environmental awareness is a process that in the latest decade is actively developing and gaining new capacity every year, so the undergraduate students, when still studying in general secondary education institutions, were much more engaged in the formation of environmental conduct. Thus, the process of environmentalization of general and professional education in Ukraine is intensifying every year and affects young people's environmental awareness.

The current practice of professional civil engineering education in Ukraine generally takes into consideration the sustainable development needs in higher education institutions, though insufficiently. Both undergraduate and graduate students are characterized by low environmental activity and limited environmental protection skills, but they have steady environmental beliefs and understandings about environmental norms, the need to comply with them in everyday life, as well in further professional activities, and the sufficient level of environmental knowledge. At the present stage, their professional training produces no significant impact on increasing the level of their environmental awareness and requires additional environmentalization and fostering theoretical aspects and motivational influence regarding the fundamentals of sustainable development.

Therefore, it is obvious that strengthening the environmentalization of the professional training of prospective civil engineering specialists in compliance with the Concept of Sustainable Development is facilitated by the unity of integrated (interdisciplinary) teaching approach and the change of pedagogical approaches, namely: developing educational and social projects, modeling, role (business) plays, practical environmental assignments, applying problem-based learning and the like. It would be useful to promote students' participation in the local and regional studies on the state of the environment, provide for the performance of complex graduate Bachelor's and Master's degree projects engaging students of different specialties on the topic to solve the sustainable development issues. One of the efficient ways of developing prospective civil engineers' environmental awareness may be the attraction of leading practicing professionals who would introduce the students to the issues of environmental security and sustainable development during lectures, seminars, and tutorials and make them familiar with the ways of solving them.

Declaration of Interest

Authors declare no competing interest.

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