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THE ISSUES OF ENVIRONMENTAL ENGINEERS EDUCATION IN TERMS OF BLOOM'S TAXONOMY

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Abstract. *The paper presents the analysis of learning efficiency for environmental engineers. The modern trends in education development demand modification of educational process in higher educational establishments to join the tuning process taking place in Europe. The essence of modification is shown to be shifting from learning requirements definition to building competencies. The existing approaches to formation and evaluation of competencies have been analyzed. The role of taxonomies in planning and evaluation process has been considered and Bloom's taxonomy has been applied for the analysis of environmental engineers training efficiency. The major problems in three domains of education by B.S.Bloom have been defined for the given occupation mastering and potential solutions have been offered.*

Keywords: Bloom's taxonomy; environmental engineer; learning domains; professional training.

1. Introduction

Reformation of education is the most typical trend of the modern time. It is aimed at tuning national educational approaches to European, US and generic world standards. The accomplishments of the past years in this field are extraordinary mixed. Specialists believe that adaptation of Ukrainian high school methods and components are the only way to quality improvement, considering the aspiration of youth for participation in the international student mobility and career making. At the same time leading educators of the country warn against total rejection of previous higher educational system, which has proved to be efficient for almost half of century.

Moreover the core problem of post-soviet education is not in failed system, but in teachers' inability to provide efficient knowledge for their students, as they constantly lack practical experience and material provision due to tottering economy and have to work with students, having world perception totally different from their own. In other words the issues of modern higher education are of both subjective and objective character.

While troubles with material provision and practical experience are to be solved by higher educations senior management and Ministry of education, the key didactic and partially philosophic issue for our education is to move from input to output approaches to education. It means that students training plan and activities must be developed to provide the best learning results, instead of the best initial study material. In this case efforts of educators will be aimed at formation of competent specialists instead of just giving as much information as possible without connection between this information and solution of applied tasks in the course of professional activity.

So, the purpose of the paper is to analyze the current efficiency of training for environmental engineers in terms of modern student-oriented approach accepted in the world educational science and in terms of building their competency.

2. The modern trends in learning outcomes evaluation

Learning outcomes formulation is conventional element of educational system, as soon as educators are used to make lists of things students must learn as a result of subject, module, year of study etc. The idea of new educational trends is to present the expected training results in the form of competencies, obtained by students [1]. Competency is a dynamic integration of knowledge, skills and abilities, formed as a result of subject or training level mastering, and it provides future specialists with the ability to perform professional activity efficiently. Here comes the most essential difference between these concepts: learning outcomes represent educators' expectations about the volume of knowledge to be acquired by a student, while competency is a real element of proficiency or professionalism, formed "within" a student. In other words clear formulation and understanding of learning outcomes is necessary to give marks and grade student's work, but clearly formulated competency is necessary for a student to be able to work and be competitive on the labour market. The gap between these concepts is the essence of the problem rooted in national higher education system. It is especially true in case of engineering specialties.

The next issue making difference between learning outcomes and competencies is the fact that the first are precise and therefore are easily evaluated and graded, while the latter are very descriptive and subjective by their essence. Currently there exist three approaches to assessing competencies: behavioral (USA), functional (Great Britain), multidimensional and integral (France and Germany) [2]. The first is totally aimed at building behavioral patterns, which will be useful for students in their professional activity. British approach, as a more traditional one, seeks integration of theoretical values and views with complex of applied abilities and skills. French educators try to build competencies providing individual professional behavior and ability to team work for the solution of common tasks. German training programs specify complex of competencies to be obtained from each subject before the training begins. Ukraine, as all independent countries with decent intellectual potential has to develop its own system for learning outcomes and competencies evaluation.

The optimal way to formation of new quality assessment system for students training with application of competencies approach involves combination of traditional methods and techniques of knowledge control with innovation approaches, aimed at complex evaluation of the competences being developed. Moreover traditional instruments must be improved within the framework of competencies approach, while innovations must be adapted to the conditions of Ukrainian higher education establishments [3].

Theoretical grounds of such quality assessment evaluation systems are represented in the form of taxonomies of different kind. They are widely developed and applied by leading educators both in foreign countries and post-soviet states. While competencies standards reflect horizontal profile of a specialist (what he knows and can), taxonomy gives vertical profile or development of the same specialists. The question, how to get the necessary, is a key one for this paper, therefore taxonomies are major tools of the further research.

3. The educational objectives taxonomies

Taxonomy is a theory of classification and systematization of complex activities, in particular intellectual abilities from the most basic to the most refined, where the highest levels are grounded on the initial simple ones [4].

The most known foreign taxonomies are developed and analyzed by B.S. Bloom, 1956; R. Butler, P. Markulis, and D. Strang, 1985; G. Gentry and A. Burns, 1981; P. Anderson and L. Lawton, 1988; W. Lewis, R. Yates and E. Gomolka, 1988; B. Joyce and B. Weil, 1979; C.J. Marker, 1982; D.R. Krathwohl, 1964; J. Bruner, 1960; S. Parnes, 1967; F. Williams, 1970; R. Treffinger, 1979; J.P. Guilford, 1966. Domestic scientists working in the field of competencies formation structure and processes are V.P. Simonov, V.P. Bespalko, V.N. Maximova, M.N. Snatkin, O.Ye. Lebedev, V.I. Teslenko, I.Ya. Lerner.

It could be said that all these authors have something similar in basic approach to their developments: they all differentiate three areas, including knowledge acquisition, skills with different levels of their application and relations, reactions, opinions. Of course terminology, dimensions and structuring within these areas are different.

The basic taxonomy to be applied for the analysis of learning process was developed by B.S. Bloom in 1956 to become the most widely accepted and cited, being translated into over 20 languages [5]. This publication came from the research that was started in 1948 in Boston by college and university examiners to develop a way to classify student learning, evolving into a full taxonomy of learning used today for everything from curriculum development to assessment at both cognitive and performance levels [6].

The original group that met in Boston considered the taxonomy a work in progress; only one of three domains of learning (cognitive) was developed by the original group in 1956. Cognitive domain was developed to help professionals in education understand levels of learning by students given intellectual capabilities. It includes six hierarchical levels, each next being built on the previous one: knowledge, comprehension, application, analysis, synthesis and evaluation in the direction to mastering occupation.

As for the other two domains, effective domain dealing with categorizing student's emotions, feelings, and behaviors came into finalization in 1962. This domain incorporates ability to receive, respond, value, organize a personal value system and finally develop a personal philosophy.

The psychomotor domain assesses students' manual and physical skills. Its framework, including imitation, manipulation, precision, articulation and naturalization was considered complete in 1972.

Although this taxonomy has been widely revised and criticized for mixing different categories, in particular specific learning outcomes (remembering, comprehension and application) and intellectual activities, necessary to achieve these results (analysis, synthesis and evaluation), it remains the most referenced and known of all other similar developments. And when talking about such interdisciplinary professional field as environmental engineering, this 'mixing' is a real benefit, enabling efficient study. Moreover, while the original materials were written in a wide-ranging manner for all educational disciplines, Bloom stated in 1971 that "ideally each major field should have its own taxonomy of objectives in its own language – more detailed, closer to the special language and thinking of its experts, reflecting its own appropriate sub-divisions and levels of education with possible new categories, combinations of categories and omitting categories as appropriate" [7, 8]. That is why we have applied Bloom's taxonomy for the analysis of environmental engineers training.

4. The cognitive process for environmental engineers training and its problems

According to the state Ukrainian requirements environmental engineers must be broad specialists having environment as their object of activity. He must be well aware about the issues of humanities and social-economic sciences, deep knowledge of natural and fundamental sciences, combined with specific disciplines matter. His working responsibilities might be of expert, prognosis, control, engineering, management, technical or educational character. The listed directions of professional activity prove that environmental engineer specialty is universal and therefore it is very hard to predict all potential working situations and tasks, which graduates must be prepared to [9]. Under such conditions it is impossible to apply the trend of humanization to the training of these specialists. In addition technologies, equipment, management tools and instruments are currently changing very quickly, to be able to adapt to these changes quickly engineers should have a broad polytechnic outlook and have comprehensive mobility of functions [10].

So, the cognitive levels, mastered by future environmental engineers could be described in the following way:

1. Knowledge necessary for environmental engineer are grounded on facts and terminology, used in the field of Autoecology and Common Ecology. This also includes facts concerning regulation of economic activity for the provision of environment protection and standards of environment quality.

2. Comprehension could be represented in understanding functions, conditions and provisions of ecosystems functioning, both natural and anthropogenically modified of artificially created. In this case comprehension is built on knowledge of such fundamental sciences as Soil Science, Hydrology, Geology, Geomorphology, Meteorology, Biogeochemistry, Toxicology, etc. These sciences are seen to be interacting and depended in learning Landscape Ecology, Human ecology, Population and Global Ecology, for example.

3. Application is a core level in building professionalism of environmental engineer, considering the fundamental character of this occupation and considerable data to learn by students. The reduction of the necessary volume of knowledge to be acquired leads to serious gaps and failure to understand the essence and objective laws of ecosystems functioning. Application is performed through the assessment of environment components condition based on standards and regularities of environmental science and corresponding legislation, calculation of permissible levels of chemical and physical impacts on the environment. An important part of this level is also presentation skills application

in mapping, databases building and processing data on biosphere pollution.

4. Analysis is the essence of environmental engineer routine work in the form of conducting Environmental Impacts Assessment, Environmental Audit, Environmental Expertise, Environmental Monitoring, Environmental Standardization and Environmental Control for industrial, agricultural and municipal facilities, protected areas and urban ecosystems. All the mentioned procedures involve analyzing the impacts of human activity to find destructive elements, threats, sources of hazard and assessing potential consequences for natural and living environment and for artificial structures.

5. Synthesis is the final level, which could be obtained in the course of professional training under current conditions of Ukrainian higher educational establishments. It includes ability to develop special or customized monitoring systems, making prognosis of environment condition, develop projects of new protected areas or plans of nature protecting activities. Accurate prognosis and detailed viable nature protecting plans are the most valuable product of environmental engineer professional activity.

6. Evaluation is a complex of abilities, obtained as a result of practical activity and continuously improved in the process of professional activity. Here it is possible to say that evaluation is equal to the management of environment quality, nature protecting activities, waste management, energy saving activities implementation, natural resources consumption and exploitation. Moreover, a student must be able to evaluate the efficiency of management plans, as well as evaluate risks of human activity, environmental safety of living conditions and make decisions about adequacy of nature protecting efforts. Finally, mastering this level makes future environmental engineers able to evaluate critically overall environmental situation and distribute financial and labour resources for its improvement.

The final two levels are partially simulated and assimilated by students during practical periods: internship, apprenticeship, field-works and trainings. The efficient organization of these periods is thought to be the most decisive for the formation of professional profile. Authors' personal experience also proves that after the summer training experiences up to 75% students are ready to answer the question, what kind of work within the occupation they are ready and interested to do and which is strictly not.

From the other side, the major problem of this domain, faced by both students and the faculty, is transition from analysis to synthesis. There is some obstacle in the form of hanging example. In other words, students are inclined to copy the existing examples, provided by professors, and it is only the imitation of synthesis. Therefore there is a need for development of new complex tasks to promote creative intellectual activity of students both individually and as a team work. Dr. Ilyushyn L.S. has developed special instrument to support training activity of educators in the field of tasks development. According to Bloom's taxonomy he has developed the Constructor of Situational Tasks, which implies the general form of tasks/problems/questions for students at each cognitive level [11]. Considering these recommendations the following complex tasks could be offered for future environmental engineers depending on the year of study:

– development of a protected area project, involving location choice and substantiation, structure and planning, necessary constructional work and territory preparation, definition of acceptable economic usage of natural resources and permissible levels of natural components transformation;

– development of tourist/recreational facility project with environment friendly type of management, including determination of functional structure, permissible recreational pressure and attractions layout in the form of ecological trails etc.

– development of special monitoring program after technogenic accidents and natural disasters;

– development of preventive actions plan to reduce health effects among the population of the settlements, exposed to specific negative technogenic impacts;

– conduction of environment management system evaluation at an enterprise;

– assessment of environment and health risks from the activity of industrial enterprises in complex and their ranking;

– ranging environmental and health threats at certain territory for the distribution of protecting activities and financial investments;

– choosing and planning the optimal way of economic development of certain territory, accounting environmental safety, ecosystem integrity and profit perspectives;

– finding the reasons of epidemic situation deterioration among the factors of environment and development of plans for the improvement of the environment condition;

– development of the plan for environmental safety improvement at urban ecosystem with application of planning solutions and green infrastructure or transport system improvement;

– development of the complex waste management plan for a settlement or industrial complex;

– development of educational materials aimed at distributing knowledge about certain environmental issues among specific groups of population and results of monitoring;

– development of indicators and benchmark values for continuous control of environment condition at specific level of certain objects;

– development of scenarios of environment condition changes under the influence of certain economic factors based on a branch of industry development prognosis;

– development of conceptual models presenting interactions between certain facilities/objects and components of the environment;

– choice and substantiation of energy saving solutions and alternative power sources for settlements, communities or industrial facilities;

– development of checklists for the control of environment protection activities at certain facilities.

5. The issues of building environmental world view and skills set for environmental engineers

As in relation to psychomotor domain, the fulfillment of the offered complex tasks represents the highest level of this domain, which is naturalization. Starting from imitation (which the initial level and must be applied only at the beginning), when working on calculation of acceptable limits of anthropogenic influence, for example, to manipulation in building standard monitoring networks and math prognosis without interpretation, a student follows the course of education and it is the minimal requirement to completed subject. It is also the basis for articulation, which turns to be a problem quite often, as students fail to understand the interactions between all their skills and knowledge obtained.

Consequently, they need direct instructions on what procedures should be conducted, methods applied and which could be combined for the best result. From this point it is necessary to practice activities aimed at offering and choosing procedures, methods and approaches most appropriate for a particular task. Such activities must be a separate group tasks, involving determination of advantages and disadvantages of analytical instruments in order to substantiate their application. This will form standard reactions or coherent sequence of actions to be applied under certain conditions. At the same time it will build professional confidence and provide future specialists with draft schemes useful in potential working conditions.

Finally, naturalization assumes ability to manipulate all skills and knowledge so that it will lead to formation of original approaches and techniques, in other words it is creative thinking under the conditions of working environment. Moreover at this level of professional competency, which must be formed up to this moment, training must be based on real objects and case studies instead of simplified tasks, developed for students. This enables comparing solutions offered by trainees with real way of things. Real problems also provide considerably wider range of details and initial conditions, important for the most efficient decision making.

Affective domain turns to be the most problematic among modern students. Currently the level of indifference to abstract values and individualism is unusually high and except raising obvious moral issues, it is a serious obstacle for mastering such professions as environmental engineering, which is totally grounded on global good and altruism and is often characterized with delayed payback of the invested efforts. This is additionally complicated due to students aiming at practical activity instead of working on theoretical tasks, necessary to form "green" world view, based on solid knowledge in the field of natural sciences.

At the same time, environmental issues are widely discussed by common public and it results in false certainty about comprehensive knowledge in this field. Thus, at the first level, when students must be ready to receive new information and experiences, educators face the problem of the need to overcome prejudices and improve delusions. Another difficulty is introduction of professional terminology instead of popular or common names. This is also displayed at the second level, which includes ability to give responses and participate in discussions. As a result, students are able to discuss questions from their field of study, but having faced the inadequacy of their previous knowledge and used terms, trainees desist from expressing their ideas. Therefore, the training process faces big difficulties in terms of building students' attitudes and beliefs and overall perception of environmental science, which will eventually form their personal environmental philosophy – the final level of effective domain or naturalization.

There is another important issue: naturalization with environmental engineering will also mean changing way of life to more sustainable. It is impossible to be good in this occupation without practicing its in ordinary life, which is quite hard with modern level of cynicism among students of higher courses, but still necessary. In the end, it will give awareness about position and importance of environmental engineering and engineers in human life to graduates and young professionals. Here they will also realize, with the help of educators, the role of environmental science not only in safety provisions, but also in the economy of the country. It is important for them to understand that environmental issues are not only restricting, but also provisional for economy, as they support life of workers and resources for production.

6. Conclusions

The system of training for environmental engineers is currently going through the problematic period. It includes both objective and subjective issues. First, there is lack of well-developed complex tasks to stimulate creative activity and independent thinking of students. This prevents integration of all obtained knowledge and formation of clear occupational patterns to be applied in professional activity. The second issue is more subjective: availability of common information on various environmental issues litters perception of students and creates additional complications for training process. The results of analysis show that there exist problems with the transition and mastering higher levels of learning process in all three Bloom's domains - cognitive, psychomotor and affective. Therefore development of engineering education cannot go the way of simplification, considering the growing volume of information and decisive role of engineering for living conditions and living needs provision.

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Наведено результати аналізу ефективності навчання інженерів-екологів. Показано, що сучасні тенденції у розвитку освіти вимагають модифікації навчального процесу у вищих навчальних закладах для забезпечення участі у процесі адаптації систем освіти, що відбувається в Європі. Вказується, що суть модифікації являє собою перехід від формулювання навчальних вимог до формування компетенцій. Проаналізовано існуючі підходи до формування та оцінки компетенцій. Розглянуто роль таксономії у плануванні та оцінці освітнього процесу, а таксономія Блума застосована для аналізу ефективності навчання інженерів-екологів. Визначені основні проблеми у трьох доменах навчання по Б.С.Блуму для даної професії та запропоновано потенційні шляхи їх вирішення.

Ключові слова: домени навчання; інженер-еколог; професійна підготовка; таксономія Блума.

М.М. Радомская[1], Л.М. Черняк[2]. Проблемы подготовки инженеров-экологов в контексте таксономии Блума
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Приведены результаты анализа эффективности обучения инженеров-экологов. Показано, что современные тенденции в развитии образования требуют модификации учебного процесса в высших учебных заведениях для обеспечения участия в процессе адаптации систем образования, происходящем в Европе. Указывается, что суть модификации представляет собой переход от формулировки учебных требований к формированию компетенций. Проанализированы существующие подходы к формированию и оценке компетенций. Рассмотрена роль таксономии в планировании и оценке образовательного процесса, а таксономия Блума применена для анализа эффективности обучения инженеров-экологов. Определены основные проблемы в трех доменах обучения по Б.С.Блуму для данной профессии и предложены потенциальные пути их решения.

Ключевые слова: домены обучения; инженер-эколог; профессиональная подготовка; таксономия Блума,

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