

Realization of Competency Approach in the Field of Ecological Education of Future Engineers

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Abstract— The article considers the issues of psychological and pedagogical aspects of training the personnel resources, able to improve the interaction between a human, nature and society. On the basis of theory and practice analysis possible ways and means of the competence approach in ecological education of future engineers are suggested in the article. The principles of selecting education content, forms, methods of realization and result assessment (indicators of ecological competence formation) in the process of studying the course of Ecology are defined. The mechanism of diagnostics and education result assessment is presented. The efficiency of the suggested way of planning and realization of the education process, measure procedures and assessment of progress in studying Ecology is confirmed by the results of the federal internet examination. The study shows that the result of applying competence approach in the sphere of ecological education is a professional of a qualitatively new level, having developed ecological awareness, experience of environmentally friendly engineer activity and ecologically oriented pattern of behavior.

Keywords — ecological education, competence approach, principles of selecting education content, fund of assessment means, ecological competence, assessment scale, program module.

I. INTRODUCTION

In the contemporary world people have started to realize the global and large-scale character of environment problems. It is the life of the human that depends on the effective solution of these problems. Thus, 2017 was declared the Year of Ecology in Russia. Conducted sociological research, different scientific and practical events (conferences, public hearings, debates, and others) have demonstrated great concern of both state bodies, social institutions and ordinary citizens about the effective solution of numerous local and large-scale environmental problems.

Nowadays the interest in the formation of graduates' ecological competence has also increased in the system of higher engineering education. The issue of improving ecological safety on the basis of advanced national and foreign achievements in the process of creating and using objects of engineer activity requires training personnel ready to solve innovation development issues of Russia under the conditions of global ecological crisis, able to improve interaction of a

human, nature and society. In this regard the notion of «ecological competence» of an engineer acquires a universal, integral, and sociocultural character, makes the foundation for professional activity and behavior, aimed at solving socially relevant environmental problems.

II. RELEVANCE, SCIENTIFIC SIGNIFICANCE OF THE ISSUE WITH BRIEF LITERATURE REVIEW

Analysis of the theoretical and practical experience of environmental education in the process of general and professional (including engineering) training has shown the multifacetedness and relevance of this problem. In the sphere of national and foreign science, researchers have already accumulated experience in:

- revealing philosophical, social, cultural and other foundations of environmental education (NA Karmaev [1], AD Ursul [2], RG Barker [3], WR Catton [4], DD Chiras [5] and others);
- defining essential, content, structural characteristics of the ecological worldview, ecological consciousness, ecological thinking as the basis for human-nature interaction (GV Akopov [6], AD Ioseliani [7], JI Chernyshova [8], DH Meadows [9], AW Wiecker [10], etc.);
- forming ecological culture as the objective of environmental education (SN Glazachev [11], NS Dezhnikova [12], II Mazur [13], etc.);
- designing and implementing the system of continuous environmental education (LV Moiseeva [14], OV Popova [15], LF Tararina [16], etc.);
- determining theoretical and methodological foundations of general ecological education and upbringing (AN Zakhlebny [17], IT Suravegin [18], etc.);
- analysis and development of methodological bases for the environmental training of specialists in institutions of professional education at various levels (EI Efimova [19], NM Mamedov [20], GA Paputkova [21], etc.).

The definition of the essence of environmental education is used to be connected with the first conference held on this topic in 1970 in Carson City (USA, Nevada). The following definition was proposed as the basic one: "Environmental education is a process of human comprehension of the value

of the environment and clarification of the basic provisions necessary to obtain the knowledge and skills necessary to understand and recognize the mutual dependence between man, their culture and biophysical environment. Environmental education also includes training practical skills in solving problems related to interaction with the environment, developing behavior that contributes to improving the quality of the environment "[22].

In accordance with the competence approach to training in higher education, the result of the environmental education of the future professional is the competence to predict, prevent or reduce the negative impact on the environment in realization of economic activities. The subject of environmental education should be able to organize its actions in such a way as to minimize or eliminate possible contamination of the biosphere. However, the traditional content of environmental education in vocational educational institutions of engineering and technology focuses mainly on the general ecology and does not allow to form the competence of applied orientation at the proper level, including in the field of ecological safety, ecological culture, ecological consciousness and self-consciousness of a person.

Thus, it can be stated that, on the one hand, the environmental component in engineering vocational education is of current importance and can in practice be expressed in the gradual strengthening of the environmental orientation of the content of a number of natural and humanitarian disciplines, the "ecological depth" of technical education, the introduction of innovative forms and methods of environmental education and upbringing, etc. At the same time, on the other hand, it is necessary to search for fundamentally new approaches to the organization of environmental education, which would really ensure the formation of future environmental engineers' competence. We consider the environmental competence of an engineer as a basic, integrative characteristic of the subject of engineering activity, consisting in the ability and readiness for the effective design and implementation of professional tasks on the basis of relevant environmental knowledge and experience of actions, environment-valued personality orientations that provide the basis for professional activity and behavior aimed at solution of socially significant environmental problems. Its structure also integrates the competencies of FSES of HE (Federal State Education Standard of Higher Education) in directions of engineering education, in the content of which there is an environmental component.

III. TASK SETTING, RESEARCH METHODS

Goal setting of the empirical research is based on the suggestion that the effectiveness of the educational process is determined by the selection of content, the choice of forms, means and methods of education. The task is to find and test the effectiveness of specific mechanisms for implementing a competence approach to the environmental education of future engineers.

In our research conducted at FSBEI of HE (Federal state Bryansk Educational Institution of Higher Education) Bryansk State University of Engineering and Technology both theoretical and empirical methods were used: observation, analysis of activity products, pedagogical experiment, questioning, testing, modeling, expert assessment, etc.

IV. THEORETICAL PART

We consider positive individual environmental responsibility of the subject of engineering activity to be an important indicator of professional competence. However, the system of environmental education of future engineers, existing in modern educational practice, is focused on preparing for the solution of narrowly focused environmental tasks typical of specific areas of the activity. It is expressed both in the procedures for planning and implementing the educational process, and in the procedures for measuring and evaluating its results.

The modern regulatory framework of the educational process provides the universities with certain independence in the selection of content, the choice of means, forms and teaching methods. In particular, the "educational program" is a set of basic characteristics of education (scope, content, planned results), organizational and pedagogical conditions, forms of attestation, which is presented in the form of a curriculum, calendar curriculum, working programs of disciplines (modules), programs of practices, other components, as well as evaluation and methodological materials ", universities develop and approve educational programs independently [23].

When implementing the competence approach in the field of environmental education of engineers, the discipline "Ecology", with the volume of at least two credits, was included in the curricula of all bachelor training areas.

The design of the environmental education content for bachelors, as well as the selection of technologies, methods and tools implemented in the university educational process, was carried out by us on the basis of the competence approach. Alongside with that, the achievements of pedagogical science and practice were summarized in such theoretical approaches as activity, personality-oriented, integrative one [24]. Thus, in the design of the education content, these approaches have made it possible not only to select the didactic units that correspond to the tasks of forming the future bachelor's readiness for performing valid and safe activities, but are also aimed at the formation of ecological consciousness, general ecological culture, personal development of the subject of the future professional activities. Integrative approach (at the substantive and procedural levels) allows to use the content of other academic disciplines in solving the tasks of environmental education in conditions of reducing the number of lecture hours. Thus, for example, the integration of the content of the academic courses "Ecology" and "Psychology and Pedagogy" allows more in-depth study of such didactic units as "ecological

consciousness and its components", "natural environment as a factor of personal development", "professional concept of personality", "environmental upbringing", etc.

Account of the basic principles of vocational training: general (scientific character, humanism, civic consciousness), content (goal-setting, unity of fundamentality and professionally applied orientation), organizational (continuity and systematic, differentiation and individualization of teaching) and methodical (consciousness and activity) enabled to attach not only fundamental and applied, but also personal direction to the education of future bachelors.

The results of education in the form of ecological knowledge, skills and possessions in the field of environmental education are the basis for the formation of competences determined by the competence matrix of the relevant educational program.

When designing the working program for the course of Ecology we have identified the following modules: "Theoretical ecology" (ecology of organisms and habitat, ecological systems, biosphere and its structure); "Applied Ecology" (anthropogenic impact on the biosphere, environmental protection, the basics of environmental management, environmental management, the economy of nature management and environmental protection, the legal framework for nature management and environmental protection). At the same time, 2/3 of the total complexity of the course is devoted to the study of the module "Applied ecology".

One of the main structural components of the working program is assessment materials presented in the form of assessment means fund (AMF) designed to estimate the level of formation of students' and graduates' competences to meet the requirements of the federal state educational standards of higher education (FSES of HE).

The results of the training in the discipline (module) are differentiated according to the criteria and indicators denoting the levels of competence formation; scales and evaluation procedures were also developed [25].

Let us consider the methods of designing the fund of assessment means on the example of Ecology course. The competences formed in the course of mastering this discipline are determined by the competence matrix of the corresponding educational program. We propose to allocate planned learning outcomes (indicators of results of its mastering) for each competence included in the structure of environmental competence of the subject of engineering activities in the context of knowledge, skills and abilities. Evaluation of the degree of competence mastering is differentiated according to five levels, the first of which implies the lack of knowledge, skills and abilities, and the fifth implies the presence of the formed systematic knowledge, skills and abilities.

Not all the proposed categories can be identified as the planned learning outcomes for the formation of the competence ("to have a good command of (a skill, method, method, technology, etc.)," to be able "and" to know"), but only a part of them, with the indicated categories being understood as:

- «to know» – how to reproduce and explain education material with the required degree of scientific accuracy and completeness.

- «to be able» – to solve typical tasks on the basis of reproducing standard solution algorithms;

- «to have a good command of» – solving complicated problems with the help of acquired knowledge, skills and abilities, with using them in nontypical situations, with the category formed in the process getting activity experience.

The scale of evaluation is based on the point-rating system implemented at the university. At the same time, the degree of conformity of content and quality of preparation to the requirements of FSES of HE is determined by the acquisition of competencies that are considered to be formed within the framework of this discipline if the student overcomes the threshold level.

A certain problem in the formation of the fund of assessment means consists in the development of tasks which allow to evaluate the level of environmental competence formation in accordance with selected indicators and evaluation criteria. The problem is that, on the one hand, the control materials should allow a qualitative assessment of knowledge, skills and possessions formed by the student, and on the other hand, quantify accurately in accordance with the established scales for assessing the level of formation of the components of the environmental competence of future engineers.

One of the tools that allow to develop control materials of this kind is the "AMF" software module, which is presented on the platform of a single portal for Internet testing in the field of education of the Research Institute for Monitoring the Quality of Education. This module allows to develop a set of methodological and control materials used to assess competencies at different stages of student training, as well as to test graduates for compliance (or inconsistency) in their level of preparation to FSES requirements in the profile of training / specialty.

Analyzing the data presented in scientific sources [27], [28] it should be noted that "AMF" is a program module of "Internet simulators in the field of education" system, which enables an educational organization to address the problematic issues connected with the creation of an internal system of quality assessment in a complex way.

The main purpose of this module is to assist in the creation of assessment funds, which, according to the requirements of FSES of HE, are developed and approved by educational organizations [27], [28].

Maintenance of the "FOS" module implies organizational, methodological and technological support from the Research Institute for Monitoring the Quality of Education. Let us consider fundamental characteristics of work with AMF module.

This program module allows to create a personal cabinet for the control materials developer, in which they can not only develop them, but also organize the work of students in the modes of "training", "self-control", "control in the teaching

mode." Development of the task base is accompanied by its structuring into sections and topics. In each topic, you can create an unlimited number of test tasks, determine the length of time assigned to one task, and set criteria for assessing competencies at the level of knowledge, skills and abilities. You can create jobs of various types in the program module.

Here are, for example, tasks with the choice of several correct answers from the proposed ones: ***There are two groups of quantitative indicators of the population... The answers are: 1) static, 2) elementary, 3) dynamic, 4) special.***

Short answer questions (input of any symbols): ***Global warming of the climate is caused by the accumulation of _____ gases in the atmosphere. (Type the word in the answer field in the corresponding form).***

Drag & drop and Flash (case studies) techniques: ***Average World water consumption is 626 cubic meters of fresh water per capita annually. The average citizen of North America spends about 1665 m³ of fresh water per year, while the citizen of Asia spends three times less. In North America, one citizen spends about _____ cubic meters of fresh water a year more than an Asian resident. (Enter the whole number with no spaces).***

It is important to take into account that when generating a test case for a particular student, only one task of any type will be selected from a single topic.

Fourthly, the AMF module has a simple interface for creating tasks, including a toolbar, fields for inputting the condition of the job, options for answers and solutions. The undoubted advantage is the ability to copy texts, drawings and formulas from other text editors.

The control materials developed with the use of the program module undergo expert review and are placed on the platform of the Research Institute for Monitoring the Quality of Education - "Internet simulators in the field of education". Thus, the use of this system in the educational process allows not only to develop control materials for assessment funds, but also to use it as a tool to evaluate the level of students' environmental competence.

Apart from specific environmental knowledge, skills and abilities, the following factors should be referred to indicators of the formed future engineers' environmental competence: the sustainability of interest in environmental problems, positive individual environmental responsibility, the need to increase the level of knowledge, skills and abilities of the environmental orientation, the motivation for participation in various activities that express value of ecological character and are personally significant for students, experience of participation in practical activities to preserve and improve the environment during construction and operation of engineering facilities.

It should be emphasized that the formation of the environmental consciousness of future engineers is impossible without the active involvement of students in research and

practical activities to address socially significant environmental problems. Such activities in the field of environmental education of future engineers are presented in the following forms:

- socio-psychological research conducted by the students in the student environment of Bryansk universities on ecological issues (for example: "Subjective assessment of the quality of life and perception of ecological factors of the environment by young people", "Investigation of factors of subjective anxiety in the educational environment of the university", etc.) with research results published and speeches made at scientific and practical conferences;
- scientific research in the field of environmental protection and participation in environmental projects (for example, "Effective Models and Technologies of Resource Saving, Energy Saving and Nature Management in Construction and Housing and Communal Services", "Environmental Environments - Natural, Technogenic, Social", etc.);
- development and implementation of environmentally significant projects in the field of engineering (for example, "Development of a waste management scheme map", "Development of land recultivation projects", etc.) [29].

All the students' achievements in the field of environmentally oriented activities, their reflection are presented in the electronic portfolio, which, as it is mentioned above, contributes to getting knowledge and practical experience, providing the basis for professional activity and behavior of future engineers [30].

The effectiveness of the proposed approach to the selection of content, forms and methods of teaching of Ecology course is confirmed by the results of the federal Internet examination in the field of vocational education, and the positive dynamics of the growth in the number of students who have mastered all the didactic units of this discipline is clearly traced. Improving the quality level of environmental education of students is also confirmed by quality certificates.

Representatives of the federation of employers, leading employees, leading experts of enterprises and organizations of the region were invited as experts to assess the effectiveness of the work in the field of environmental education. Quality monitoring of the experimental impact lasted three years.

As the evaluation criteria, we have identified the motivation and value, cognitive, activity, reflective components of the environmental competence of the engineer, which are reflected in the following indicators: manifestation of a steady interest in the environmental component of the professional activity of the engineer; manifestation of the desire to choose environmentally friendly methods of solving engineering problems; knowledge of environmentally friendly methods and means of solving engineering problems; an excellent command of methods and means for solving ecologically significant engineering tasks; a good command of methods and means for assessing the results of engineering

activities on environmental factors of the environment; a good command of self-assessment of one's own professional activity results in the system of interaction with the surrounding natural and man-made environment, the presence of positive individual environmental responsibility, the sustainability of interest in environmental problems, the need for increasing the level of knowledge, skills and abilities of environmental orientation, and others.

We have noted the agreed opinion of 96 expert employers (concordance ratio $W = 0.94$, criterion $\chi^2 = 331.4$, with $p = 0.95$) about stable positive dynamics in the level of formation above these indicators characterizing the environmental competence of future engineers.

Summarizing the above, it can be concluded that the result of the competence approach implementation in the field of environmental education of engineers is forming a professional of a qualitatively new level capable of solving urgent environmental problems from the perspective of a subject of professional activity possessing ecological competence.

V. RESULTS

The formation of environmental competence as an integrative characteristic of a modern engineer is an urgent task of higher professional education.

The effectiveness of the competence approach in the sphere of environmental education of future engineers is predetermined by the principles of the selection of content, forms and methods of influence and interaction of subjects of the educational process.

The experimental work has shown that an interdisciplinary approach to the formation of the required competence allows modeling the educational environment and methodological materials, providing a transition to the professional-value level of professional competence.

The composition of Ecology working program has a module character and assumes the variability of the assessment means. Critically grounded assessment tools developed by the teacher within the framework of the basic educational program, and external expertise in the form of the federal Internet examination and expert assessment by employers provide the maximum result of assessing the quality of Ecology education.

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