PERIÓDICO TCHÊ QUÍMICA

Volume 16 - Número 32 - 2019 ISSN 2179-0302

Órgão de divulgação científica e informativa

www.periodico.tchequimica.com

PERIÓDICO TCHÊ QUÍMICA

ISSN - 1806-0374 (Impresso) - ISSN - 1806-9827 (CD-ROM) - ISSN - 2179-0302 (Online)

Volume 16 **Número 32 – 2019** **ISSN 2179 - 0302**

Órgão de divulgação científica e informativa.

Dados Internacionais de Catalogação na Publicação (CIP)

Periódico Tchê Química: órgão de divulgação científica e informativa [recurso eletrônico] / Grupo Tchê Química – Vol. 1, n. 1 (Jan. 2004)- . – Porto Alegre: Grupo Tchê Química, 2005 - Semestral.
Sistema requerido: Adobe Acrobat Reader.
Modo de acesso: World Wide Web:
<http://www.tchequimica.com>

Descrição baseada em: Vol. 16, n. 31 (JAN. 2017).
ISSN 1806-0374
ISSN 1806-9827 (CD-ROM)
ISSN 2179-0302 (Online)
1. Química. I. Grupo Tchê Química.
CDD 540

Bibliotecário Responsável
Ednei de Freitas Silveira
CRB 10/1262

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PERIÓDICO TCHÊ QUÍMICA • www.periodico.tchequimica.com • Vol. 16 N. 32.
• ISSN 1806-0374 (impresso) • ISSN 1806-9827 (CD-ROM) • ISSN 2179-0302 (meio eletrônico)

PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

A POSIÇÃO DA COMPETÊNCIA AMBIENTAL NA ESTRUTURA DA PREPARAÇÃO ORIENTADA POR PRÁTICA DE ESTUDANTES DE ENGENHARIA

THE POSITION OF ENVIRONMENTAL COMPETENCE IN THE STRUCTURE OF THE PRACTICE-ORIENTED PREPARATION OF ENGINEERING STUDENTS

ПОЛОЖЕНИЕ ЭКОЛОГИЧЕСКОЙ КОМПЕТЕНТНОСТИ В СТРУКТУРЕ ПРАКТИЧЕСКО-ОРИЕНТИРОВАННОЙ ПОДГОТОВКИ СТУДЕНТОВ-ИНЖЕНЕРОВ

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Received 06 March; received in revised form April 15 2019; accepted 02 May 2019

RESUMO

O ambiente é a base para a existência e desenvolvimento da humanidade em geral. Como mostra a história do desenvolvimento da civilização, são exatamente as relações com a natureza e a integração do ser humano com o ambiente que formou muitas visões culturais no meio social. No entanto, o constante desenvolvimento das tecnologias declara a falta da necessidade na integração do ambiente. Não existe um sistema de educação ambiental na formação de especialistas no contexto geral, não apenas na forma de adaptação a uma determinada profissão. A novidade do estudo é definida pelo fato de os autores do manuscrito mostrarem a oportunidade de formar a cultura ambiental dos futuros engenheiros na estrutura geral de sua formação profissional. Foram apresentados os aspectos do desenvolvimento estrutural dos engenheiros como as principais fontes de impacto tecnogênico no meio ambiente. Eles também formaram os parâmetros básicos da alocação de atividades ambientais entre os engenheiros e apresentaram as oportunidades de aumentar a cultura ambiental com base na introdução de métodos pedagógicos específicos durante seu treinamento. O significado prático do estudo é definido pelo fato de que a cultura ambiental no futuro próximo definirá as oportunidades de seu próprio desenvolvimento e a transformação de toda a sociedade em geral.

Palavras-chave: *estudante, engenheiros, especialização em programas educacionais, competência ambiental, prática.*

ABSTRACT

The environment is the base for the existence and development of humanity in general. As shown by the history of the development of civilization, it is exactly the relations with nature and the integration of the human being with the environment that formed many cultural views in the social environment. However, the constant development of the technologies declares the lack of the need in the integration of the environment. There is no system of environmental education in the training of specialists in the general context, not only in the form of adaptation to a particular profession. The novelty of the study is defined by the fact that the authors of the paper show the opportunity of forming the environmental culture of future engineers in the general structure of their professional training. They showed the aspects of the structural development of engineers as the main sources of technogenic impact on the environment. They also formed the basic parameters of the environmental activities' allocation among the engineers and presented the opportunities of increasing the environmental culture based on the introduction of particular pedagogical methods during their training. The practical significance of the study is defined by the fact that the environmental culture in the nearest future will define the opportunities of its own development and the transformation of the entire society in general.

Keywords: *student, engineers, educational program specialization, environmental competence, practice*.

АННОТАЦИЯ

Окружающая среда является основой для существования и развития человечества в целом. Как показывает история развития цивилизации, именно отношения с природой и интеграция человека с окружающей средой сформировали множество культурных взглядов в социальной среде. Тем не менее, постоянное развитие технологий заявляет об отсутствии необходимости в интеграции окружающей среды. Не существует системы экологического образования при подготовке специалистов в общем контексте, причем не только в форме адаптации к конкретной профессии. Новизна исследования определяется тем, что авторы статьи демонстрируют возможность формирования экологической культуры будущих инженеров в общей структуре их профессиональной подготовки. Они показали аспекты структурного развития инженеров как основных источников техногенного воздействия на окружающую среду. Они также сформировали основные параметры распределения природоохранной деятельности среди инженеров и предоставили возможности для повышения экологической культуры на основе внедрения определенных педагогических методов во время их обучения. Практическая значимость исследования определяется тем, что экологическая культура в ближайшем будущем будет определять возможности ее собственного развития и трансформации всего общества в целом.

Ключевые слова: *студент, инженеры, специализация образовательной программы, экологическая компетентность, практика.*

1. INTRODUCTION

The general state of education in the conditions of introduction of the state standards of the new generation is tightly connected with the concept of professionalization and a narrower specialization at the level of the university graduates. In the conditions of technological education, such forms of obtaining a narrower specialization may be aimed at forming among the specialists of a wider knowledge of various social problems that will subsequently be reflected in the professional activities (Mioduser, 2015). Such problems may also include the environment. The engineer solves the problems of technical nature which will consequently become the base for the development of the social environment in general. And at the same time, it is important to define the balance that is particularly kept by the environment. In this regard, the relevant thing is the extent an engineer is ready for the understanding of the bases of environmental activities (Kazanin et al., 2019).

The applied aspect is also the fact that the engineer when performing his/her work may also translate environmental knowledge to his/her colleagues (Montoya, 1974). In this regard, a relevant fact is also that the professional translating his/her knowledge should be open to the processes of environmental education, especially at the university (Savina, 2015). So, one should show the dynamics of the future engineer's relation to the process of environmental education.

The general goal of environmental education is the development of the environmental culture among the people (Hovardas, 2013). The bases of environmental culture are laid at school, where children first face with the knowledge of nature. Their further attitude towards nature will depend on whether they are aware of its value, and on the level of their moral and aesthetic attitude towards natural objects (Song *et al.*, 2017). Engineer should have such personal traits as the communication culture, aesthetic of look and behavior; culture of relationships with and the attitude towards the environment; careful attitude towards thing, objects, books, work-related belongings; care of the environment (plants, animals, water bodies, monuments and constructions etc.); high artistic-aesthetic taste, adequate environmental-aesthetic judgements and estimates; highly-developed environmental ideal; environmental mindsets; the need in the environmental self-improvement, self-education; the singularity of environmental knowledge, interests, judgements and realia of behavior; and the intolerance to the violation of the environmental standards and laws (Kobori, 2016; Gridina and Andreev, 2016).

Besides, at the university, the future engineer should obtain a certain amount of environmental knowledge, learn the psychological aspects of environmental activities, master the environmental skills of rational activities; the skills of creating positive emotional-environmental atmosphere, both in the process of particular lessons and during the entire work (Meléndez-Ackerman, 2011).

Apparently, the effectiveness of environmental education is defined by the level of the environmental culture, i.e., the engineer should first be the carrier of the environmental culture him/herself (Petrina, 2000). High level of environmental culture is determined with the recognition of the uniqueness of nature's value by itself regardless of its utilitarian significance for the human. The task is to inform everybody that everybody is responsible for the preservation of the natural resources of the planet and is able to do something for it (Martinez-Maldonado *et al.*, 2014). However, it is not enough when people just know it, and it is necessary for them to gain practical skills on the preservation of the natural resources, such as water, electricity, fuel, heat, and food.

2. LITERATURE REVIEW

Environmental culture of the engineer is a system of knowledge and skills, value orientations of a person in the sphere of technology, industry, art, habits, and traditions, as well as the readiness to the vigorous activities on the preservation and improvement of the environment (Nisar, 2015). This special kind of culture is characterized by an aggregate of environmental knowledge, factors of nature management, respectful humanistic attitude to flora and fauna (Thompson, 2015). Environmental culture is manifested in the system of spiritual values, all kinds, and results of human activities connected with the cognition and transformation of nature expressing the character and qualitative level of the relations between the society and nature (Brown *et al.*, 2014; Kazanin and Rudakov, 2016).

The process of development of the environmental culture of the future engineer in the modern conditions of priority development of common cultural components of higher education requires the conduction of in-depth methodological, theoretical studies and the development of special approaches to the construction of the motivational, content and processual components of the education-education process's model (Johnson and Catley, 2009; Kazanin et al., 2019).

When organizing the experimental research work, we based on the fact that the orientation on the future engineer's environmental culture development will contribute to eliminating the gap between the increase in the general cultural level and the culture of the attitudes towards nature (Cockerill, 2004). It is namely the engineer who chooses the ways of entry to the society's environmental culture through the development of the worldview, environmental direction, environmental consciousness and reasoning (Bonnett, 2018).

The professional competence of the engineer is not only defined with the basic knowledge and skills, but also by the value orientations, motives of the activities, understanding of their position in the word and the world around them, the style of relationships with people, the ability to understand and affect the spiritual world of people, general culture, and the ability to develop their creative potential (Hovardas and Korfiatis, 2011). The unity of the general cultural, social-moral development of a person actualizes the engineers' development of environmental culture (Bennett and Bennett, 2004; Gendler et al., 2015).

From the perspective of cultural anthropology, the notion of environmental culture implies the creation of a new system of relations not only between nature and the society but also in the society (in the society and its subsystems) and in the interaction of a person with him/herself (Bogner and Wiseman, 1997). In this regard, relevant is the development of the social-cultural, intellectual, moral potential of a personality of the engineer, his/her capacity of implementing creative processes in the broad sense (Hokanson, 2017). The values and norms of environmental culture of the society, morality, achievements of the spiritual sphere of life should create the conditions for the professional development of the future engineer (Isenmann, 2007).

As for the engineer, the environmental culture, to our mind, is the aggregate of general humanistic ideas, professional-significant qualities of personality, universal ways of cognition, and the humanistic activities (Anderson *et al.*, 2014). Environmental culture is a professional position of the engineer, the system of his/her relations, goals, mindsets, motives, and skills add sustainability to the professional characteristics of the engineer.

Environmental culture becomes a personal achievement of the future engineer only in case of its formed practical criterion that embraces the aggregate of actions, activity on the creation of the conditions for the implementation of the obligations, requirements, revealing of the independence, initiative, persistence, and creativity in the environmental and labor activities.

3. MATERIALS AND METHODS

The experimental methods for environmental-pedagogical preparation of the future engineer were aimed at the following purposes:

a) to assist the student in mastering the methods for solving professional problems based on the principles of formation of ecological culture of technological education;

b) to assist in the comprehension of the ways for constructing the concepts of environmental education work and own concept of the engineer considering the peculiarities of education;

c) to find ways for implementing the conceptual schemes in the practical experience in the organization of environmental education;

d) to provide an opportunity in the comprehension of the effectiveness of the pedagogical novelties in the sphere of environmental education.

The implementation of the experimental methods for the preparation of the engineers to environmental education was conducted gradually. The environmental preparation of the future engineer was performed by the following stages:

1) value-motivational – the development of the environmental worldview, environmental reasoning, personal readiness to the preservation of nature, protection of nature and environmental education;

2) educational-training – targeted preparation to the environmentalization of work;

3) practical-creative – practical implementation of the environmental knowledge, development of the skills of implementing natural preservation, natural protection, and environmental-industrial activities.

At the value-motivational stage, the experimental methods were aimed at the education of the following typical traits of the student's personality:

a) the skill to observe and admire nature;

b) the idea of the basic notions describing the interaction between an organism and the environment;

c) the skill to reveal and denote these interactions;

d) the conviction in the people's involvement to the natural processes and tight connection between the human and nature;

e) the involvement to the study of nature.

The value-motivational stage was ensured with the focus on the education aspects of environmental-professional preparation, which were implemented the following way:

1) the creation of the environmentalized educational system (planting, natural sites, winter gardens, green beds, beautification, etc.) and the choice of the objects for communication with nature (environmental paths, excursion routes, places of natural preservation, etc.);

2) the development among the students of attentiveness and subjective attitude towards nature based on the perception-affective cognitive and practical channels of the informational perception;

3) the development of the system of knowledge, skills, behavior, and the activities directly outdoor using the innovational training technologies.

The most important task of this stage of introduction of the experimental methods was the development of the environmental reasoning; the development of the emotional-value sphere (attitude towards self, people and nature). The result of this stage was the development of the environmental-value-creative position of the future engineer.

At the educational-training stage, we implemented the wide-scale environmentalization of the professional disciplines' content in order to form the students' system of environmental knowledge and methodical tricks of transferring this knowledge to the colleagues during the working activities. The result of the educational-training stage implying the environmentalization of the knowledge on the profile disciplines implied the development among the future engineers of different kinds of competencies, namely:

a) informative-cognitive competence manifesting in the students' digestion of the environmental knowledge, as well as in the ability to obtain the environmental information from different sources, particularly from the mass media and distinguish the scientific, prescientific and commercial positions;

b) value-oriented competences which are expressed in the acceptance by the students of the value system disclosing the harmony of people and nature; as well as in the students' awareness of the need in the ethic environmental imperative;

c) regulation-behavior competence expressed in the development of the environmental mindsets, the readiness to follow the environmental standards of behavior, to accept the independent solution of the city's environmental problems, to bear the responsibility for their actions, to implement environmentally feasible activities;

d) pedagogical-environmental competence implying the engineer's readiness to the constructive interaction with nature, with the colleagues, with the information means, the ability to organize different kinds of education events and measures in the course of ideas of tolerance and empathy.

The practical-creative stage implied the development among the students of the information-environmental, natural protection, and art-practical environmental activities. This direction was implemented due to the attraction of the students to the participation in the education events and measures of environmental direction. The practical-creative stage also implied the participation of future engineers in particular environmental labor activities, environmental education measures, and environmental-aesthetic contests.

4. RESULTS AND DISCUSSION:

General indicators of the engineer's environmental culture are defined as follows:

1) interest in nature;

2) general educational and special environmental knowledge (knowledge on nature, interconnection in nature, human's impact of on nature);

3) positive activities and behavior in nature;

4) knowledge of safety precautions and behavior in the environment;

5) the awareness of the goals and tasks of environmental education;

6) the knowledge of psychological peculiarities of the environmental culture development;

7) the command in technologies, tricks of planning and management of the environment preservation process at the industry.

The criteria of the engineer's environmental culture should be correlated with those innovations and capacities emerging in the process of professional training, self-education self-development and further work (Muravyeva, 2008). The criteria of high environmental culture, to our mind, may be considered as follows: the high rating of environmental values; personal perception of environmental problems; social setting to the strong contribution to the preservation of the environment and the healthy lifestyle; high level of general culture, and the readiness to the environmental education.

The notion of an environmental culture of the future engineer includes as follows:

a) the culture of the students' cognitive activities on the acquisition of the human experience towards nature as to the source of material values, the base of the environmental conditions of life, and the object of emotional feelings;

b) the culture of labor formed in the process of labor activities considering the environmental, aesthetic and social criteria at the implementation of particular tasks in different areas of environmental management;

c) the culture of spiritual communication with nature;

d) the culture of health as a specific way of thinking, perception, and behavior with the creative vector to the development and implementation of their own health and the health of the other people (Maslennikova *et al.*, 2017).

On summing up the above-said, we suggest the following system of criteria and indicators of the labor education teacher's environmental culture (Table 1).

Each indicator was assessed according to the 5-point system. The assessment included 12 expert teachers dealing with the professional disciplines, as well as the monitors of the students' groups. The attraction of the monitors to the assessment is considered a necessary condition because it is namely the monitors of the students' groups who have an opportunity to observe the behavior of their students in the household and outdoor, to conduct collective discussions of the environmental problems, and to implement individual conversations with the students.

Table 2 presents the numerical values of the indicators obtained in the control and experimental groups before and after the experiment.

After the conduction of the experimental research work according to the described methods, it has turned out that the numerical values in the experimental groups are significantly higher. In order to prove the accidental nature of the differences in the numerical data before the experiment and the regular nature after the experiment, we will use the formula of calculating the criteria of the significance of the differences (agreement criteria (Eq. 1-4)):

The intermediate results of the calculations are presented in Table 3 (before the experiment) and in Table 4 (after the experiment).

In the groups before the experiment, the agreement criterion turned out to be equal to $t \approx 0.67 < 3$, which evidences the accidental nature of the difference between the numerical values of the indicators. Experimental were the groups with the least values of the indicators. After the conduction of the experiment, we repeatedly defined the numerical values of indicators of the environmental culture in the control and experimental groups (Table 4). The results of the calculations after conduction of the experiment provided the value of significance criteria of the differences $t \approx 4.03 < 3$, which evidences that the difference of the indicators in the CG and EG is significant. It provides the grounds to consider that the development of future engineers' environmental culture will be significantly affected by the experimental methods.

However, the development of the engineer's environmental culture was not the only goal of the experimental research work. The main task was the development of the readiness to environmental education. The results of the future engineer professional preparation for environmental education are the readiness of the students to the implementation of these activities. The criteria that allow judging on the future engineer's readiness to the implementation of the labor activities considering environmental education are as follows:

1) cognitive interest in these activities;

2) personally-significant sense of implementation of such activities;

3) the level of theoretical knowledge on the kinds and ways of the environmental education implementation;

4) the level of development of the knowledge system necessary for the successful implementation of environmental education;

5) the level of development of the reflection position and positive self-perception.

The structure of preparedness of the future engineer to environmental education also includes such indicators as:

a) high level of environmental knowledge; the knowledge of the modern educational technologies in the sphere of education;

b) the knowledge of the environmental situation and the main directions of the state policy in the sphere of nature protection;

c) the skill to organize different kinds of activities in nature in order to form a caring attitude towards it;

d) the skill to analyze and generalize the advanced experience in the sphere of the environmental culture education;

e) the attitude towards nature as a value;

f) the aspiration to increase the level of environmental culture.

So, the readiness of the engineer to the environmental education is defined from the perspective of the development of the personal integral structure containing the cognitive, emotional, motivation-will and conative spheres.

The cognitive component is a dialectical system of the environmental and environment-related knowledge, the values of the professional activities, as well as a particular style of thinking and the vision of the system of environmental relations. The emotional sphere is connected with the development of the spiritual-moral and emotional manifestations towards the outer world, as well as self-assessment of compliance of their own traits with the professional requirements. The motivation-will sphere reflects the social-moral position of the future engineer in solving the problems of the environmental education, his/her activities in the development of the humanistic traits, the convictions in need of careful attitude towards natural resources. The cognitive component is the implementation of all the other spheres of professional activities included in the implementation of the environmental worldview in the professional and social-cultural space and is manifested in the substantiation of the choice of the ways for the achievement of the goals of the environmental-technical process, and the modeling of the environmental-professional activities.

Except for the personal and professional readiness to environmental education, which should be peculiar to any engineer, we suggest also considering the environmental labor activities in order to consider the specificity of the lessons. So, the readiness of the future engineer to the environmental education is presented as a system of three components (personal, environmental labor, and technological), and the aggregate of the criteria, which were ensured gradually: motivational, axiological, cognitive, and organizational-processual (Table 5).

In order to define the effectiveness of the experimental methods and the effectiveness of its influence on the engineer's readiness to the implementation of the environmental education (EU) in the labor activities, each indicator was detailed and divided into the measurable ones (Table 6). Table 7 presents the averaged numerical values of the indicators in each component and criteria.

The numerical values of indicators of the motivational and axiological criteria were defined using the test-questionnaire, cognitive one – according to the results of the students' academic performance by the special disciplines; organizational-processual – based on the observations over the students' work during the pedagogical practice.

Table 7 shows that numerical values of all the indicators in the experimental groups are higher. In order to assess the differences in the future engineers' readiness to the environmental education by the criteria, we will construct the following graph (Figure 1).

The graphs of Figure 1 shows that in both groups, the future engineers' readiness to the environmental education by the axiological criteria prevail. The lowest in the control and experimental groups is the readiness according to the cognitive criteria, but in the experimental groups, the differences in the indicators by the criteria are not so significant compared to the control ones.

To prove the effectiveness of the experimental research work, we will find the value of the normative deviation t according to the Student's formula (Eq. 5), where $\overline{x_K}$ and $\overline{x_E}$ – average point in the control and experimental groups respectively, and for our case n_1=4 and n_2=4. The intermediate values of the calculation are presented in Table 8.

Student's coefficient turned out to be equal to t = 6.39. Based on the table of values S(t) for distribution of Student for $n=n_1+n_2-2=6$, we will find S(6.4)=0.999. Let us calculate the probability of the accidental nature of the successfulness deviation in both types of the students' groups (Eq. 6).

As the probability is very small, then it shows that the numerical values of the indicators in the experimental groups differ from the numerical values of the indicators in the control groups.

To assess the differences in the readiness of the students from the control and experimental groups to the environmental education of the students with the components, we will consider the graph in Figure 2. It shows that in the control groups the practical component of readiness prevails, while in the experimental ones – the environmental labor component. It may be explained by the fact that in the experimental groups the experimental research work was predominantly focused on the enforcement of the environmental labor component.

To assess the dynamics of the students' professional-environmental skills during the application of the experimental methods by stages (value-motivational, educational-training and practical-creative stages), we highlighted four levels of the future engineer's readiness to the environmental education: indifferent (zero), empirical-emotional (low), information-cognitive (average) and active-creative high).

Indifferent level is peculiar to those students who are indifferent to the state of the environment, see no environmental problems, do not understand the aesthetical potential of nature, and see no need in the environmental education. The other three levels imply some readiness of the students to the environmental education activities. The empirical-emotional level is characterized by the understanding of the environmental problems, the involvement in the beauty of nature, the desire to join the nature preservation labor activities and the environmental education work. However, this level is characterized by the lack of the necessary knowledge of the environmental state of our planet, country, region and the technology of the environmental labor and the environmental education activities. The above-mentioned environmental, technological and pedagogical knowledge characterize the information-cognitive level of readiness to environmental education, but at this level, there is still no necessary skills of environmental labor and the environmental education activities. Only developed skills of nature preservation, and nature protection labor activities and the command in the technologies of environmental education work ensure for the future engineer the active-creative level of readiness to an environmental education in the process of labor activities.

At the estimate of the dynamics of the formed levels, we used the complex of the following methods: monitoring, questionnaires, tests, academic performance estimates, and creative works. All these methods were fully used both in the experimental (EG), and control (CG) groups. The generalized data are represented in Table 9, where zero, low, average and high levels are denoted as 0, l, a, h respectively.

The table shows that each year the number of students reached average and high levels increases. However, in the control groups at two first courses, low level prevails, and only at the third and fourth ones, they reach the average level. In the experimental groups, the average level prevails as early as from the second course, while at the fourth course 47.3% reach a high level of readiness.

If to analyze the quality of the future engineers' preparation quality to the environmental education also evaluating the successfulness considered qualitative in pedagogics when achieving 70%, then we can see that in the control groups even after the 4th course the quality is only equal to 62.8%. In the experimental groups, the quality of the preparation to the environmental education activities as early as from the second course was equal to 78.8%, after the third one – 85.9%, and after the fourth one – 87.6%.

As shown by the table, the experimental groups during the experiment underwent significant changes towards the growth of the number of students, the level of readiness to the environmental education of which reached a high level. To compare it with the results in the control groups, we will build the graph of the distribution of the number of students with a high level of readiness to the environmental education activities (Figure 3).

Figure 3 shows that qualitative changes in the experimental groups are much more intense than in the control ones. Thus, the obtained qualitative data allow concluding that the suggested methods for the development of the future engineers' readiness for environmental education may be deemed as quite effective.

5. CONCLUSIONS:

The result of the practical environmental preparation of the engineer is his/her level of the environmental culture development, which is based on the logical combination of the value-motivational, cognitive and practical components. The development of the high level of the future engineers' environmental culture ensures the ability to join the solution of the environmental problems together with the colleagues and forecasting the consequences of the nature management activities.

The generalization and comparison of the empirical data evidence that the experimental data of the future engineers creates favorable conditions for the development among the students of the value-oriented attitude towards nature, take a positive impact on the process of their personal development.

The results of application of the author program in the educational process obtained at each stage of the experimental work and supported by the data of application of the mathematical statistics' methods reflect the tendency towards the increase in the level of the future engineers' readiness to the environmental education, which proves the effectiveness of the developed methods and allows considering the conducted research as successful.

6. ACKNOWLEDGMENTS:

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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Table 1. *The criteria and indicators of the future engineers' environmental culture*

Criteria	Indicators	
Value-Motivational	VM1	the awareness of the value of nature
	VM2	the awareness of the responsibility for the preservation of nature
	VM3	the understanding of the need in the preservation of the environment for the future generations
	VM4	the need in nature protective activities
	VM5	the ability to admire the beauty of nature
	VM6	the aspiration to communicate with nature
	VM7	the awareness of the importance of environmental education
	VM8	the desire to take on the environmental education;
	VM9	understanding need in nature protection labor activities
	VM10	the desire to organize the nature protection activities
Cognitive	C1	the understanding of the essence of nature transformative human activities
	C2	the knowledge of the harmful influence of the industry on nature
	C3	the knowledge of the environmental problems of the native region, country, and the world
	C4	the nature protection skills
	C5	the command in the technology of the energy saving process
	C6	the knowledge of the recycling technologies in various areas
	C7	the knowledge of the domestic waste
	C8	the knowledge of the domestic chemistry's harm on the human health
	C9	the knowledge of the chemical fertilizers' harm
	C10	the knowledge of the alternative ways of energy, technology, and fertilizers
Practical	P1	the ability to forecast the consequences of their own actions and activities
	P2	the ability to harmonize the interaction with the environment
	P3	the environmentally feasible behavior in the household
	P4	the environmentally feasible behavior at the recreation
	P5	the skills and experience in solving local environmental problems
	P6	participation in the promotive and environmental-educational activities
	P7	the ability to the organization of the nature protection events and measures
	P8	the involvement in the art and creative works of environmental nature
	P9	the ability to manufacture the items from natural materials
	P10	the ability to use household wastes in the art and creative activities

Table 2. *The numerical values of indicators of the environmental culture in the control and experimental groups*

Criteria and indicators	Before the Experiment		After the Experiment	
	CG	EG	CG	EG
VM1	4.15	3.42	4.11	4.53
VM2	3.41	3.41	3.90	4.45
VM3	2.87	3.89	2.82	4.54
VM4	4.33	3.55	3.43	4.43
VM5	4.05	4.02	4.09	4.51
VM6	3.21	3.16	3.24	4.26
VM7	3.81	3.68	2.62	4.44
VM8	3.63	4.11	3.67	4.41
VM9	3.51	3.51	3.54	4.43
VM10	3.94	3.85	4.17	4.37
C1	4.1	4.23	4.12	4.48
C2	3.51	3.82	3.54	4.52
C3	3.34	3.99	3.28	4.11
C4	3.31	4.18	3.35	4.18
C5	3.27	3.25	3.47	4.25
C6	3.56	3.17	3.56	4.17
C7	3.42	3.15	3.42	3.85
C8	3.41	3.38	3.41	3.92
C9	3.79	3.87	3.69	3.94
C10	3.55	3.33	3.55	4.16
P1	4.02	3.25	4.32	4.15
P2	4.16	3.21	4.16	4.28
P3	3.88	3.8	4.28	4.29
P4	4.11	3.63	4.11	4.23
P5	3.91	3.51	3.91	4.15
P6	3.85	3.94	3.85	4.24
P7	3.83	3.41	4.23	4.17
P8	3.69	3.68	4.39	4.78
P9	3.74	4.12	3.84	4.22
P10	3.45	4.18	4.15	4.76
Average Indicator for all the Criteria	3.694	3.657	3.741	4.307

Table 3. *Intermediate results of Calculation of the agreement criterion (before the experiment)*

No.	**CG**	$(x_K - \bar{x})^2$ **CG**	**EG**	$(x_E - \bar{x})^2$ **EG**
VM1	4.15	0.137	3.42	0.056
VM2	3.41	0.137	3.41	0.061
VM3	2.87	0.829	3.89	0.054
VM4	4.33	0.302	3.55	0.011
VM5	4.05	0.073	4.02	0.132
VM6	3.21	0.325	3.16	0.247
VM7	3.81	0.001	3.68	0.001
VM8	3.63	0.023	4.11	0.206
VM9	3.51	0.073	3.51	0.022
VM10	3.94	0.025	3.85	0.037
C1	4.1	0.102	4.23	0.329
C2	3.51	0.073	3.82	0.027
C3	3.34	0.194	3.99	0.111
C4	3.31	0.221	4.18	0.274
C5	3.27	0.26	3.25	0.165
C6	3.56	0.049	3.17	0.237
C7	3.42	0.13	3.15	0.257
C8	3.41	0.137	3.38	0.077
C9	3.79	0	3.87	0.046
C10	3.55	0.053	3.33	0.107
P1	4.02	0.057	3.25	0.165
P2	4.16	0.144	3.21	0.2
P3	3.88	0.25	3.8	0.021
P4	4.11	0.109	3.63	0.001
P5	3.91	0.017	3.51	0.022
P6	3.85	0.005	3.94	0.08
P7	3.83	0.202	3.41	0.061
P8	3.69	0.372	3.68	0.001
P9	3.74	0.129	4.12	0.215
P10	3.45	0.137	4.18	0.274
	Average Value 3.647	Sum 2.418	Average Value 3.605	Sum 1.620

Table 4. *Intermediate results of calculation of the agreement criterion (after the experiment)*

No.	CG	$(x_K - \overline{x})^2$ CG	EG	$(x_E - \overline{x})^2$ EG
VM1	4.11	0.136	4.53	0.050
VM2	3.9	0.025	4.45	0.020
VM3	2.82	0.848	4.54	0.054
VM4	3.43	0.097	4.43	0.015
VM5	4.09	0.122	4.51	0.041
VM6	3.24	0.251	4.26	0.002
VM7	2.62	1.256	4.44	0.018
VM8	3.67	0.005	4.41	0.011
VM9	3.54	0.040	4.43	0.015
VM10	4.17	0.184	4.37	0.004
C1	4.12	0.144	4.48	0.030
C2	3.54	0.040	4.52	0.045
C3	3.28	0.212	4.11	0.039
C4	3.35	0.153	4.18	0.016
C5	3.47	0.073	4.25	0.003
C6	3.56	0.033	4.17	0.019
C7	3.42	0.103	3.85	0.209
C8	3.41	0.109	3.92	0.150
C9	3.69	0.003	3.94	0.135
C10	3.55	0.036	4.16	0.022
P1	4.32	0.336	4.15	0.025
P2	4.16	0.176	4.28	0.001
P3	4.28	0.291	4.29	0.000
P4	4.11	0.136	4.23	0.006
P5	3.91	0.029	4.15	0.025
P6	3.85	0.012	4.24	0.005
P7	4.23	0.239	4.17	0.019
P8	4.39	0.422	4.78	0.223
P9	3.84	0.010	4.22	0.008
P10	4.15	0.168	4.76	0.205
	Average Value 3.741	Sum 5.688	Average Value 4.307	Sum 1.414

Table 5. *Criteria and indicators of readiness of the future engineer to the environmental education*

	Criteria	Indicators
C1	Motivational	The desire to take on the environmental education and organization of the nature protection activities
C2	Axiological	Awareness of the importance of environmental education, the understanding of the value of nature and the need in its preservation
C3	Cognitive	The presence of environmental knowledge, nature protection skills, command in the technologies of the environmental industry processes
C4	Organizational-Processual	The organization of the natural protection measures and events, environmental-educational and environmental education activities

Table 6. Components, criteria, and indicators of the future engineer's readiness to the environmental education

Criteria	Components		
	Personal	**Environmental Labor**	**Practical**
Motivational	MO1 – involvement In the study of the environmental situation MO2 – the aspiration to the deeper environmental knowledge MO3 – the aspiration to the preservation of one's own health MO4 – the aspiration to increase the level of one's own environmental culture	AE1 – the aspiration to environmental responsibility of labor activities AE2 – an attempt to adopt the nature preservation industrial technologies AE3 – the desire to take on the nature preservation activities AE4 – the aspiration to the resource saving	MP1 – love to the profession MP2 – aspiration of professional self-improvement MP3 – the aspiration to increase the level of environmental culture of the population MP4 – the aspiration to environmental education
Axiological	AO1-awareness of the natural value AO2-understanding of the natural aesthetics AO3-awareness value of ecology as a science AO4-understanding of the value of the personal environmental culture	AE1-awareness of the value of the environmental knowledge AE2-awareness of the value of labor for human development AE3-understanding of the need in the nature preservation labor activities AE4-understanding of the need in nature protection labor activities	AP1 – understanding of the connection between the labor and environmental working procedure AP2 – understanding of the value AP3 – respect to the human being as to the highest value AP4 – understanding of the value of environmental culture
Cognitive	CO1 – knowledge of the environmental situation in the world CO2 – knowledge of the environmental situation in the country, region, and city CO3 – knowledge of the standards and laws of the environment CO4 – knowledge of the environmental household rules	CE1 – knowledge of the recycling technologies CE2 –knowledge of the harm of production CE3 –knowledge of the forms of nature protection activities CE4 – knowledge of the nature preservation technologies	CP1 – knowledge of the education technologies CP2 – knowledge of the working technology CP3 – knowledge of the age peculiarities CP4 – knowledge of the professional peculiarities
Organizational-processual	OO1 – participation in the nature protection events and measures OO2 – intolerant attitude towards the violators of the	OE1 – general labor skills OE2 – the skill of formation of ecological culture of the contents OE3 – the skill of	OP1 – general skills OP2 – the skill of analyzing and generalizing the advanced experience OP3 – the skill of introducing the

	environmental standards and laws OO3 – environmentally suitable outdoor behavior OO4 – environmentally suitable behavior in the household	organizing the aesthetical-environmental activities OE4 – the skill to organize nature protection activities	technologies to the labor process OP4 – the skill of implementing the formation of ecological culture of the activities

Table 7. *Numerical values of the indicators of the future engineer's readiness to the environmental education*

Components									**Average Value of the Criterion**	
Personal			**Environmental Labor**			**Practical**				
Indicators	CG	EG	Indicators	CG	EG	Indicators	CG	EG	CG	EG
MO1	3.2	4.1	ME1	3.7	4.2	MP1	4.2	4.4		
MO2	3.1	4.2	ME2	3.4	4.1	MP2	3.1	4.1	3.52	4.31
MO3	4.1	4.5	ME3	3.5	4.2	MP3	3.2	4.3		
MO4	3.8	4.3	ME4	3.3	4.6	MP4	3.6	4.7		
AO1	4.1	4.6	AE1	3.6	4.4	AP1	3.8	4.2		
AO2	4.2	4.8	AE2	3.8	4.7	AP2	3.7	4.3	3.74	4.44
AO3	3.8	4.1	AE3	3.5	4.6	AP3	3.6	4.2		
AO4	3.6	4.5	AE4	3.7	4.6	AP4	3.4	4.3		
CO1	3.2	3.9	CE1	2.7	3.9	CP1	3.6	4.1		
CO2	3.3	4.1	CE2	2.9	4.2	CP2	2.8	4.3	3.19	4.21
CO3	2.8	3.8	CE3	3.1	4.4	CP3	3.9	4.4		
CO4	3.1	4.4	CE4	2.7	4.3	CP4	4.1	4.7		
OO1	2.8	3.5	OE1	3.9	4.1	OP1	4.2	4.3		
OO2	3.1	4.2	OE2	3.0	4.2	OP2	3.8	4.1	3.28	4.22
OO3	2.9	4.3	OE3	3.2	4.6	OP3	2.6	3.9		
OO4	3.2	4.5	OE4	3.6	4.5	OP4	3.1	4.4		
Average Value of the Component	3.39	4.24		3.35	4.35		3.54	4.29		

Table 8. *Intermediate calculations of the student's coefficient*

	CG(x_K)	$\left(x_K - \overline{x}\right)^2$	**EG** (x_E)	$\left(x_E - \overline{x}\right)^2$
	3.52	0.00766	4.31	0.00022
	3.74	0.09456	4.44	0.02103
	3.19	0.05881	4.21	0.00722
	3.28	0.02326	4.22	0.00563
Average Value	3.433		4.295	
N	4		4	
sum		0.18428		0.0341
			t=6.3936	

Table 9. *Dynamics of distribution of the students from the control and experimental groups by the levels of their readiness to environmental education (final assessments at the end of each course)*

Groups	**1st Course**				**2nd Course**				**3rd Course**				**4th Course**			
	Levels				Levels				Levels				Levels			
	0	l	a	h	0	l	a	h	0	l	a	h	0	l	a	h
CG	18.1	73.5	6.2	2.2	2.3	60.1	31.1	6.5	0.0	40.2	51.4	8.4	0.0	37.2	51.3	11.5
EG	2.6	79.0	14.1	4.3	0.0	21.2	60.1	18.7	0.0	14.1	61.5	24.4	0.0	12.4	40.3	47.3

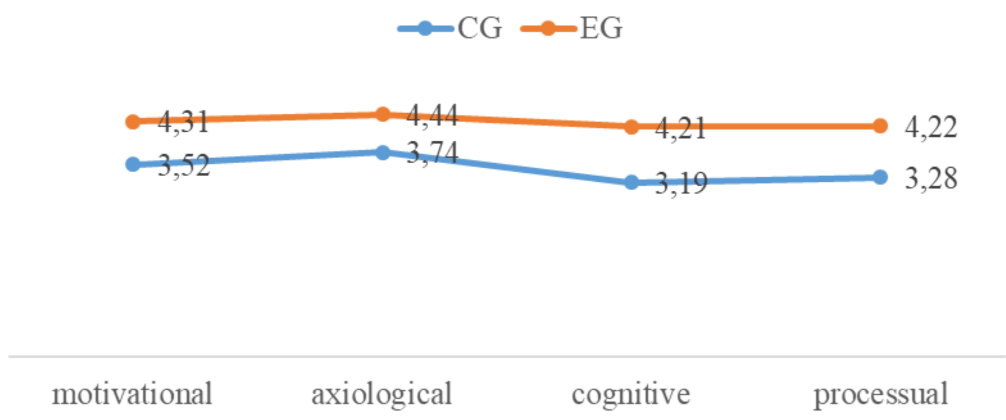

Figure 1. *Differences in the future engineers' readiness to the environmental education by the criteria*

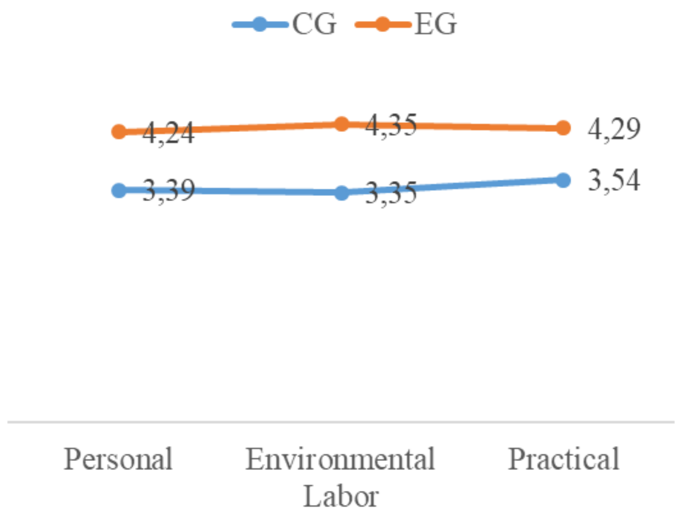

Figure 2. *Differences in the readiness of the students from the control and experimental groups to the environmental education with the components*

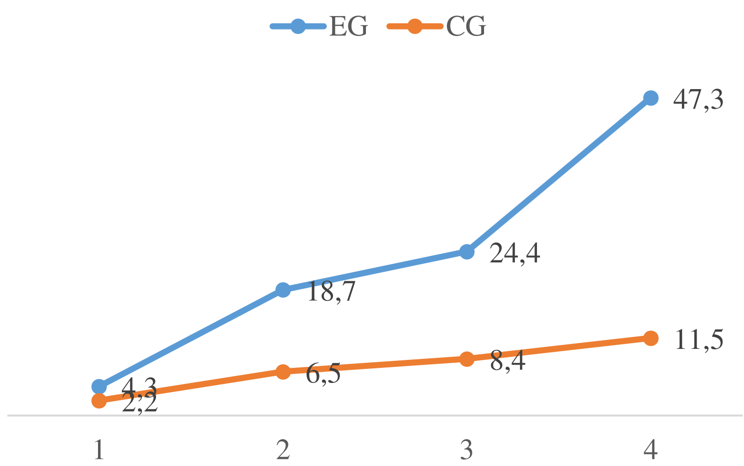

Figure 3. *Dynamics of the number of students with high levels of readiness to the environmental education activities*

$$t = \frac{v_E - v_K}{\sqrt{\frac{v_E^2}{2n_E} + \frac{v_K^2}{2n_K}}},$$ (Eq. 1)

$$v_E = \frac{\sigma_E}{\overline{\overline{x_E}}},$$ (Eq. 2)

$$v_K = \frac{\sigma_K}{\overline{\overline{x_K}}},$$ (Eq. 3)

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})}{n-1}},$$ (Eq. 4)

$$t = \frac{\overline{x_2} - \overline{x_1}}{\sqrt{\frac{\left(\sum_{i=1}^{n_1}\left(x_i - \overline{x_K}\right)^2 + \sum_{j=1}^{n_2}\left(x_j - \overline{x_E}\right)^2\right)(n_1 + n_2)}{(n_1 + n_2 - 2)n_1 n_2}}},$$ (Eq. 5)

$$P\left|\overline{x_2} - \overline{x_1}\right| > t_f = 2\left(1 - s(t_f)\right) = 2(1 - 0{,}999) = 0{,}002,$$ (Eq. 6)