PERIÓDICO TCHÊ QUÍMICA
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A COMPREENSÃO SUBJETIVA DO ESTUDANTE AO USAR RECURSOS EDUCACIONAIS ABERTOS

SUBJECTIVE UNDERSTANDING OF THE STUDENT WHEN USING OPEN EDUCATIONAL RESOURCES

СУБЪЕКТНОЕ ПОНИМАНИЕ СТУДЕНТА ПРИ ИСПОЛЬЗОВАНИИ ОТКРЫТЫХ ОБРАЗОВАТЕЛЬНЫХ РЕСУРСОВ

BAZYLOVA, Baglan[1*]; ZHUSUPOVA, Zhanna[2]; KAZHIGALIEVA, Gulzhan[3]; ONALBAYEVA, Aigul[4]; KALININA, Valentina[5];

[1,3,4,5] Kazakh State Women's Teacher Training University, Department of Russian Language and Literature, Almaty – Republic of Kazakhstan

[2] K. Zhubanov Aktobe Regional State University, Department of Pedagogy, Psychology and Primary Education, Aktobe – Republic of Kazakhstan

** Correspondence author*
e-mail: baglan_5_3@mail.ru

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RESUMO

A relevância do estudo se deve ao fato de que os recursos educacionais abertos têm a capacidade de se livrar do desenho metodológico básico que complica o processo de aprendizagem entre os estudantes, ou seja, de usar a experiência internacional no ensino e na aquisição de conhecimento. Este estudo mostra aspectos do funcionamento dos recursos educacionais abertos e sua base tecnológica. A novidade do trabalho reside na formação de um modelo de uso de recursos educacionais abertos na preparação de cursos especializados do Departamento de Química Aplicada. Os autores mostram que a eficácia do uso de recursos educacionais abertos depende diretamente da proporção de aprendizagem on-line e do isolamento tecnológico das disciplinas. Em particular, não apenas os processos educacionais são levados em consideração na implementação do programa de química aplicada, mas também outras disciplinas que exigem a troca de experiências entre países e o uso de uma ampla gama de equipamentos tecnológicos e uma estrutura on-line. Em particular, se considera o treinamento no exemplo de bancos de dados, redes de informação e outras estruturas espacialmente distribuídas. A importância prática do estudo é determinada pelo fato de que o uso de recursos educacionais abertos não só intensificará o processo educacional na universidade, mas também determinará a possibilidade de integração no espaço educacional global.

Palavras-chave: *Recurso educacional, eficácia educacional, departamento de química aplicada, ensino superior.*

ABSTRACT

The relevance of the study is determined by the fact that open educational resources carry the ability to overcome the basic methodological construct complicating the learning process among students and namely the use of international experience while learning and obtaining knowledge. This study shows the aspects of functioning open educational resources and their technological basis. The novelty of the work was the formation of a model for the use of open educational resources in training of specialized courses of the Department of applied chemistry. The authors showed that the effectiveness of open educational resources use depends directly on the share of online learning and technological isolation of subjects. In particular, not only learning processes in the implementation of the program in applied chemistry, but also other disciplines that require the exchange of experience between countries and the use of a wide range of technological equipment and online structure are considered. In particular, training on the example of databases, information networks, and other spatially distributed structures are considered too. The practical significance of the study is defined by the fact that the use of open educational resources will not only intensify the learning process at the university, but also to determine the possibility of integration into the world educational space.

Keywords: *Educational resource, educational efficiency, Department of applied chemistry, higher education.*

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АНОТАЦИЯ

Актуальность исследования обусловлена тем фактом, что открытые образовательные ресурсы имеют способность изживать основную методологическую конструкцию, усложняющую процесс обучения среди студентов, а именно использовать международный опыт при обучении и получении знаний. В данном исследовании показаны аспекты функционирования открытых образовательных ресурсов и их технологическая база. Новизна работы заключается в формировании модели использования открытых образовательных ресурсов при подготовке специализированных курсов кафедры прикладной химии. Авторы показывают, что эффективность использования открытых образовательных ресурсов напрямую зависит от доли онлайн-обучения и технологической изоляции предметов. В частности, учитываются не только учебные процессы при реализации программы по прикладной химии, но и другие дисциплины, которые требуют обмена опытом между странами и использования широкого спектра технологического оборудования и онлайн-структуры. В частности, рассматривается обучение на примере баз данных, информационных сетей и других пространственно распределенных структур. Практическая значимость исследования определяется тем, что использование открытых образовательных ресурсов позволит не только интенсифицировать учебный процесс в университете, но и определить возможность интеграции в мировое образовательное пространство.

Ключевые слова: *Образовательный ресурс, образовательная эффективность, кафедра прикладной химии, высшая школа.*

1. INTRODUCTION

In situations where information technologies are becoming more affordable, pedagogues have found that digital educational resources are an important part of the learning process. In 1994, the term "training object" was introduced into the circulation to refer to digital materials that are being developed for multiple-use (Cheung, 2019).

In 1998, based on a study of the essence of the concept, "open content" showed that the principles of the movement of "open software" can also be applied to the content of the resource (or its content) (Sampson *et al*., 2012; Li, 2016; Delimont *et al.*, 2016; Crozier, 2018). According to the classical definition, the term "open" means granting additional copyright permissions to information in excess of those granted by standard copyright law (Kourbetis and Boukouras, 2014; Rahayu and Sapriati, 2018; Kinskey *et al.,* 2018; Adygezalova *et al.* 2018).

These additional permissions are expressed as follows: Reuse – the right to reuse the material in its unaltered form (Pande, 2018); Revise – the right to adapt, correct, modify or alter the content of the material itself (Peters, 2017); Remix – the right to combine the original or revised content of the material with other objects to create something new (Sherimon *et al.,* 2018a); Redistribute – right to share copies of the original material (Sherimon *et al.,* 2018b; Tappeiner *et al*., 2019; Lin, 2019).

In 2002, Massachusetts Institute of Technology (MIT) made a significant contribution to the development of the concept of open educational resources when it launched the "Open Course Ware" project while opening free access to the materials of its training courses. Since 2018, the world organization of UNESCO has been actively supporting initiatives to create open educational resources on the Internet (hereinafter-OER). According to the experts of this organization, OER is of particular importance in developing countries since their use can significantly increase access to quality higher education and lifelong learning, as well as ensure the full participation of universities in the creation of the world system of higher education (Annand and Jensen, 2017; Mishra, 2017; Xiao *et al.*, 2018; Navarrete and Luján-Mora, 2018; Horn *et al.*, 2018; Tappeiner *et al.,* 2019; Vogus, 2019; Aleksandrova *et al.*, 2019).

According to UNESCO's definition, open educational resources are training, educational or scientific resources placed in the public domain or distributed under a license that permits their free use or processing. Open educational resources include complete courses, teaching materials, modules, textbooks, videos, texts, software and any other means, materials or technologies used to provide access to knowledge (Volchik and Maslyukova, 2019).

The purpose of the pedagogical experiment was to identify the differences between the two empirical distributions.

2. LITERATURE REVIEW

The world pedagogical community has developed many practical recommendations regarding general principles for creating and using open educational resources. Here are some of them (Duval *et al*., 2011). It would be advisable for higher education institutions:

– develop different strategies for using OER in their own scientific and educational activities (Banerjee, 2018);

– encourage the creation of new and adaptation of existing educational resources to achieve the objectives of the institution in various fields of activity (educational process, scientific and economic activities). This primarily will be an effective step towards the establishment of an educational repository of a higher education institution (Hou *et al*., 2013);

– encourage the scientific and pedagogical staff of the educational institution to create OER by using moral and material measures (Rennie and Mason, 2010);

– provide access to the OER of all interested persons, primarily students, and teachers, subject to the copyright of the developers;

– encourage the open publication of scientific works of the educational institution, which will contribute to the improvement of its world and national ranking (Minguillón, 2010).

It would be advisable for scientific and pedagogical staff of higher educational institutions:

– grant their own research the status of "open" in order to increase their scientific authority (Schaffert, 2010);

– create teams together with students to develop OER, which will enhance their learning activities (Kopp *et al.*, 2017);

– use the principle of openness to promote their own discipline. Experts note that it can be not only parts of educational information but also booklets, promo videos, presentations of training courses, photos, works of the best students (Becker, 2012; Jaggars *et al.*, 2018);

– use OER for creating communities of practitioners from relevant fields of scientific activity, which will stimulate the expansion of professional contacts between teachers of different educational institutions (Li, 2013; Li and Wong, 2015; Feldman-Maggor *et al.*, 2016).

In Russia, some steps have been taken to promote open educational resources. Thus, Magna Charta Universitatum, signed in 1999, includes in academic freedom the open access to information, with exceptions provided by law, including scientific information through the development of open electronic archives (University institutional repositories), open electronic journals of universities and the ability to freely maintain relationships with their colleagues in any part of the world (Cheung, 2018).

Educational resources give the benefits that students need them to get additional information on these issues to share their views and discuss the learning process with other students and the teacher (Nasongkhla and Donaldson, 2018). Teachers have the opportunity to create courses more effectively using multimedia resources that require special technical and media skills, learn new teaching methods, create resources and discuss them with colleagues, join professional communities. Educational institutions can demonstrate educational and scientific programs to a wide audience, attract more applicants, reduce the cost of developing training courses. It is clear that any educational institution or scientist while creating an open educational resource strives to ensure that its copyrights are respected. The international community has developed a specific mechanism sponsored by Creative Commons (Li and Wong, 2015; Hilton, 2016; Islim and Cagiltay, 2016; Cobb, 2018; Hajri *et al.*, 2019).

3. MATERIALS AND METHODS

A pedagogical experiment can cover a group of students, a faculty, a University or several universities. The determining role in the experiment belongs to the scientific hypothesis. Based on the observations, the hypothesis has been formulated that the introduction of OER will contribute to the expansion of the information educational environment of the University and its structuring and forensic methodology of use of OER will contribute to the formation of ICT competences of future bachelors of the Department of applied chemistry increasing the level of their training. By means of pedagogical experimentation reliability of the hypothesis on increasing level of professional training of applied chemistry bachelors has to be checked.

Experiments always involve some kind of comparison, usually between a control group of students trained using the traditional method (without using OER), and an experimental group, in our study it is a group of students who studied using OER. Scientific and pedagogical work was carried out during 2013-2018 and covered five stages of scientific and pedagogical search:

1) Diagnostic stage (2013-2014), – during period in which the state of training bachelors of Department of applied chemistry in higher education in Russia and abroad has been analyzed; identified and formulated were contradictions that can be solved through the introduction of distance learning technologies in universities, based on a systematic approach, by deploying a system of support for distance learning at all levels of training: from pre-University training, training bachelors, specialists and masters, to postgraduate education and training of scientific and pedagogical workers;

2) Prognostic stage (2014), at that stage, were defined the main goals and objectives of the study, implemented the prediction results and developed the program of pedagogical experiment and formulated the main principles and provisions of OER use; OER has been rolled out within the University;

3) Organizational stage (2014), which identified the list of disciplines of chemical cycle, disciplines of cycle of professional and practical training of the future bachelors of the Department of applied chemistry; determined were the control and experimental groups for carrying out the pedagogical experiment; prepared were educational and working programs of the disciplines that were included in the pedagogical experiment;

4) Practical phase (2014-2017), in which was developed and implemented e-learning courses of the following disciplines: "Basics of distance learning", “Chemistry of higher organic compounds", "Organic chemistry", "Analytical chemistry", "Chemistry of higher inorganic compounds" for students of 1-4 courses held sections of knowledge to track changes in learning outcomes of students in the experimental groups.

5) Synthesis stage (2017-2018), which reviewed experimental work: performing tasks, achieving goals and documenting results of the experiment; prepared the relevant conclusions on the results of the experiment.

Tasks of pedagogical experiment: identify the requirements for the preparation of bachelors of the Department of applied chemistry in universities in Russia and abroad; identify the requirements for the material and technical support of the experimental site; analyze existing teaching methods using ICT and OER; prepare guidelines for the use of distance learning technologies on the preparation of bachelors of the Department of applied chemistry; conduct a survey among teachers and students to determine the status, problems and prospects of training bachelors of the Department of applied chemistry; by results of pedagogical experiment to formulate conclusions and to define prospects of further research of a problem; identify the differences in the preparation of bachelors of the Department of applied chemistry on traditional methods and training from training with the use of OER.

Goals of pedagogical experiment: teach students to understand the essence of processes and phenomena arising in the professional activities of chemical technology specialists; form students' ability to think, to give estimates, to analyze the received educational data; develop skills of working with OER universities; develop students' skills and abilities to use OER in independent work.

The following research methods were used to achieve the goals, objectives, tasks and hypothesis testing: theoretical analysis of psychological-pedagogical, scientific-technical and educational-methodical literature on the subject of research; study and generalization of pedagogical experience; didactic modeling; method of information analysis for the formulation of basic definitions and concepts used in the study; learning experience and collecting information about the learning process and the use of OER in the preparation of bachelors of the Department of applied chemistry; modeling of pedagogical processes for the deployment of OER universities; monitoring and testing method to determine the readiness of students and teachers to use OER; survey methods; inquiries and interviews with teachers and students on the use of OER; pedagogical experiment to confirm the effectiveness of the proposed method of using OER in the preparation of bachelors of the Department of applied chemistry; statistical processing of experimental data and their interpretation; generalization and prognostic methods for formulating conclusions, recommendations and determining directions for further research.

Fisher’s criterion is designed to compare two samples by frequency of occurrence of the effect (indicator) of interest to the researcher. The larger it is, the more significant are the differences. The criterion evaluates the reliability of differences between the percentages of the two samples in which the effect of interest (indicator) is registered. Figuratively speaking, the 2 best pieces cut from 2 pies are compered and it is decided which one is really bigger. The essence of Fisher's angular transformation is to convert percentages into values of the central angle, which is measured in radians. A larger angle φ will correspond to a larger percentage, and a smaller fraction will correspond to a smaller angle, but the ratio is not linear: By increasing divergence between the angles φ1 and φ2 and increasing the number of samples the value of the criterion increases. With higher value φ* more likely it is that the differences are significant.

Hypotheses. H0: The proportion of individuals who exhibit the studied effect in sample 1 is not more than in sample 2. H1: The proportion of individuals who exhibit the studied effect in sample 1 is more than in sample 2. Graphical representation of the criterion φ*. The angular transformation method is somewhat more abstract than the other criteria. The formula followed by E.V. Gubler in calculating the values φ assumes that 100% will be formed by the angle φ = 3,142, i.e. the rounded value π = 3,14159 ... This allows us to represent the comparable samples in the form of two semicircles, each of which symbolizes 100% of the size of your sample. Percentages of subjects with the effect will be presented as sectors formed by central angles φ. The criterion φ* makes it possible to determine whether one of the angles is statistically significantly superior to the other for given sample sizes.

Limitations of criterion φ*. 1. None of the matched fractions should be equal to zero. Formally, there are no obstacles to the application of the φ method in cases where the proportion of observations in one of the samples is 0. However, in these cases, the result may be unduly inflated. 2. There is no upper limit in the criterion φ. Samples can be arbitrarily large.

The lower limit is 2 observations in one of the samples. However, the following ratios in the number of the two samples should be observed: if there are only 2 observations in one sample, there should be at least 30 in the second sample; if one of the samples has only 3 observations, the second should have at least 7; if one of the samples has only 4 observations, the second should have at least 5; by $n_1,n_2 \geq 5$ any comparisons are possible. In principle, it is possible to compare samples that do not meet this condition, for example, with the ratio n_1=2, n_2=15, but in these cases, it will not be possible to identify significant differences. The criterion φ* has no other restrictions.

4. RESULTS AND DISCUSSION:

Within the first phase of the study (2013-2014) was carried out a stating stage of pedagogical experiment, which goal was the allocation of competences of bachelors of the Department of applied chemistry and the study of the level of competences of future specialists in accordance with the curriculum. The training content of bachelors of Department of applied chemistry has been analyzed as well as training methods and means were selected and the leading role of ICT in the preparation of bachelors of Department of applied chemistry defined. The available software and hardware used in the learning process have been analyzed: hardware, multimedia equipment, local and global networks, software and the like.

The investigations carried out allowed to conclude that the level of formation of professional competences of bachelors of the Department of applied chemistry is insufficient, and the introduction of OER in the educational process of the University in the information society and the requirements of the labor market requires a systematic approach. Literary sources analyzed provided an opportunity to conclude that the formation of professional and cultural information of the bachelors Department of applied chemistry should be widely introduced in the educational process ICT and OER through the OER resources and services, as a part of integrated University IOS, providing support for the educational process on a daily, part-time (distance) forms of education.

In order to determine the readiness of students to use ICT in the educational process was conducted entrance survey. As a result of the survey among 132 first-year students of the training direction "Chemical technologies" it was determined that: 99% of students have e-mail and use it; 99% of students can register on websites and download files from the Internet; 87.5% of students are familiar with chat and forum; 99% of students passed computer testing; 40% of students are familiar with OER; Internet usage level: 17.5% – beginner, 77.5% – advanced user, 5% – specialist; most students have an average level of chemical disciplines 7-9 points on a 12-point scale (60%), the remaining 40% have sufficient and high levels.

The conclusions obtained as a result of statistical processing of students' answers to the questionnaire provided an opportunity to determine the need to improve the level of formation of professional competencies through the systematic use of OER in the educational process on the basis of OER.

During the second stage of the study (2014-2015), the state of development of the research problem was determined, the program of experimental research was created. The existing methods of training using OER have been analyzed. The educational and working program of the experimental discipline "Chemistry of higher organic compounds" was developed. Classes in the discipline of the CHOHOC with the use of OER have been started. The analysis of the training level on 1st-year students, their knowledge, skills, and abilities in the disciplines of chemical and technological orientation has been developed.

The search stage of the pedagogical experiment was conducted at the Russian technological University at the faculty of chemical technologies. To increase the level of formation of professional competences of bachelors of the Department of applied chemistry in RTU-MIREA, since 2014-2015, it was proposed to conduct classes using OER and OER tools that implement them: providing remote consultations, organization of forums and chats of the most complex issues of educational programs of disciplines, automated entrance control, computer-oriented lectures and laboratory work, computer testing and surveys.

As approbation in the educational process of the developed method of using OER was chosen discipline of free choice of higher education institution "Chemistry of higher organic compounds", which is studied in the first year in the second semester. The educational and methodical complex of discipline "Chemistry of higher organic compounds" was created with the following content: general information about the course, entrance control from course, theoretical training material of course module, materials for the practical training for the course module, students' independent work, attendance control, ongoing monitoring from course, reports on the implementation of tasks for classes and independent work of the module, topical control on module, module control, semester control on the course (examination), monitoring the safety of knowledge (delayed control, the rector's control, AAC (Fateev and Fateeva, 2016).

According to the results obtained after the entrance survey, the adjustment of the structure of CHOHOC course, its methodical system of training and relevant didactic materials was carried out, and namely: all lectures on the course are relaunched as format*.ppt (presentations); most of the lectures of the course are presented in flash format (videos); task of all laboratory work is set out in the OER; mobile access to UIS of discipline in OER is set up; module for sending reports of activities and assessments was configured.

The results of statistical processing of semester control on CHOHOC discipline showed the effectiveness of developed methods of OER using, which contributed to improving the quality of student performance in the discipline "Chemistry of higher organic compounds". To study the effectiveness of the developed methodology of OER using by means of OER the students passed the output test.

Figure 1 shows the statistics of answers of students' experimental group (132 people) on the issues of the output survey, in which they noted that the system of support distance learning helps them in the preparation of such learning activities as: lectures (33.3%), laboratory work (70.8%), practical exercises (33.3 per cent), independent work (33.3 per cent), and modular control (54.2%), and final test (50%). As a result, the level of cognitive activity of students increased.

Thus, during the second phase of the study: analysis of the training level by bachelors of the Department of applied chemistry was carried out; OER was set up; OER for disciplines "Organic chemistry", "Analytical chemistry", “Methods of physical and chemical analysis” was prepared; manual for working with OER of universities was developed; method of OER using in the electronic training course through means of OER was developed.

On the third forming stage of the pedagogical experiment (2015-2017) has been identified and verified the efficiency and effectiveness of the proposed method of using OER in teaching these subjects: “Organic chemistry” of 2 courses, "Analytical chemistry" of 3 courses, "Physical and Chemical Methods of analysis" in the 4th year.

The experiment covered up to 303 students of specialty "Chemical technology" (undergraduate). Statistical processing of results of scientific-pedagogical experiment and evaluation of the effectiveness of the developed technique use of distance learning technologies in training of bachelors in Department of applied chemistry in the RTU-MIREA was carried out by using methods of mathematical statistics. The aim of the pedagogical experiment was to identify the differences between the two empirical distributions. Comparison of indicators of success of training of students of experimental and control groups of the specified disciplines by means of Fisher's criterion has been carried out. At the forming stage of the pedagogical experiment, the following results were obtained.

While checking the effectiveness of the proposed methodology for the OER using by teaching the discipline "Organic chemistry" (OC) in the 2nd year it has been found that the formulated hypothesis H1 proportion of students in the experimental group, which according to the results of the semester exam on the discipline OC have got a score of "excellent" or "good" more than in the control group. This means that the quality of student performance of the experimental group according to the results of semester control at the rate is higher than the quality of education of students in the control group, indicating that the efficiency of the proposed method of using OER in teaching discipline OC. Figure 2 shows a diagram of success when comparing the CG and the EG on the subject "Organic chemistry".

When testing the effectiveness of the proposed method of OER using in teaching on discipline "Analytical chemistry" (ANCM) for a 3 course it has been found that according the formulated hypothesis H1 the proportion of students in the experimental group, who according to the results of the semester examination in the discipline ANCM have "excellent" or "good" more than in the control group. This means that the quality of student performance of the experimental group according to the results of semester control at the rate of ANCM is higher quality of academic performance of students in the control group, indicating that the efficiency of the proposed method of using OER in teaching discipline ANCM. Figure 3 shows a diagram of success when comparing the CG and the EG in the discipline "Analytical chemistry".

When testing the effectiveness of the proposed method of OER using in teaching the discipline "Physical and chemical methods of analysis" (PCHMA) in the 4th year it was revealed that according to the formulated hypothesis H1 the proportion of students who, according to results of the semester examination for the discipline PCHMA have a positive assessment in the experimental group more than in control group. This means that the level of training success of students of the experimental group is higher than the level of performance of students of the control group, which indicates the effectiveness of the proposed method of using OER in teaching the discipline of PCHMA. Figure 4 shows the diagram of success at comparison of KG and EG on discipline "Methods of physical and chemical analysis". The results of the statistical processing of pedagogical studies data from four of these curriculum areas of training chemical technology confirm the effectiveness of the proposed methods of using distance learning technologies in training of bachelors in Department of applied chemistry, resulting in improving outcomes and/or quality of performance.

The application of the proposed method of OER using contributed to improving the quality of student performance, which makes it possible to confirm the hypothesis of the study in terms of improving the level of professional training of future specialists in chemical technologies. In Table 1 the distribution of semester exam scores on the discipline "Chemistry of higher organic compounds" at the ascertaining stage of pedagogical experiment is given. Control and experimental groups at the forming stage of the pedagogical experiment were formed in this way (Table 2):

– control group (CG) included the 1st year students of RTU-MIREA, who studied at the specialty "Chemical technology": in the second semester of the 2012-2013 academic year (group KT 801, PR 802) and in 2013-2014 (group KT 901, PR 902). Students of the control group were trained according to the traditional method (without the use of OER);

– experimental group (EG) included the 1st year students of RTU-MIREA, who studied at the specialty "Chemical technology": in the second semester of the 2014-2015 academic year (group KT 101, PR 102) and in 2015-2016 (group KT 111, PR 112). Students of the experimental group were trained according to the traditional method (with the use of OER).

The scheme of formation of KG and EG at the forming stage of the experiment on the discipline "Chemistry of higher organic compounds" by years of training are presented in table 4.2. Analysis of the semester exam results in 2012-2013 and 2013-2014 in the CHOHOC discipline allows us to conclude that the primary grade is “satisfactory” (D-E), which indicates an insufficient level of knowledge on this discipline (Table 3).

To test the hypothesis that there were no differences between the knowledge levels of students in the control and experimental groups, the results of a semester exam in general chemistry were selected, which were processed through the multifunction criterion φ* by Fisher (F is a criterion Fisher's angular transformation). By using the criterion is evaluated the significance of differences between the proportions (in percent) of two empirical samples in which the effect of interest by a researcher is recorded.

Fisher's criterion has insignificant limitations: 1) none of the particles to be compared should not be equal to zero; 2) lower boundary for the number of observations in the sample for the criterion will be equal to 2, but it is necessary to adhere to certain ratios in the number of both samples: if n_1=2, so n_2≥30; if n_1=3, so n_2≥7; if n_1=4, so n_2≥5; by n_1=5 and n_2≥5 any comparisons are possible;

3) the upper limit for the number of observations in the sample for the criterion is practically absent, that is, the samples can be arbitrarily large.

There are no other restrictions for the Fisher's criterion. The distribution of final grades in control and experimental groups according to the results of the semester exam in the discipline "General Chemistry" of 1st-year students is shown in Tables 4 and 5. Table 6 summarized data on the results of the semester exam in the discipline "General chemistry" in the control and experimental groups. Note that the final grade in the discipline "General chemistry" for the experimental groups of 100 points system was transformed into the traditional four-point scale.

Based on the data given in table 6, firstly the reliability of the absence hypothesis, from a statistical point of view, of differences between the quality indicators of the teaching "General chemistry" of students in experimental and control groups has to be checked. Hypotheses will be formulated: H0: The percentage of students passed the semester exam in "General chemistry" with grade "excellent" or "good" in the experimental group is no more than in the control group; H1: The proportion of students passed the semester exam in "General chemistry" with grade "excellent" or "good" in the experimental group is greater than in the control group.

A table that actually represents a table of empirical frequencies according to two values of the attribute: students who got grades "5" or "4", and students who received grades "3" or "2" (Table 7) is constructed. At the same time, only proportions corresponding to observation are used in the calculations, for which the effect takes place. Based on the data given in Table 8 and despite the fact that the quality indicator for the semester exam in "General Chemistry" is 33.3% and 38.9%, respectively in favor of the experimental group, while using Fisher's criterion, the hypothesis that there are no differences between the knowledge levels of students in the control (n = 66) and experimental (n = 54) groups, thus "quality of performance" is selected as an indicator for comparison.

As can be seen from Table 7 the level of achievement of students in the control group in comparison with the student achievement level of the experimental group in the discipline "General chemistry" is 0.6% lower. The performance indicator in the discipline "General chemistry" for the experimental group is higher in comparison with the control groups by 5.6%. For the average score, there are the following results: 3.4 and 3.4 of semester exam in "General chemistry" for control and experimental groups. According to the corresponding Table 9, the value of IP correspond to the shares of 33.3% and 38.9% in the corresponding groups:

$$\varphi_1(38.9\%) = 1.347$$
$$\varphi_2(33.3\%) = 1.230$$

Then the empirical definition φ* using the formulae is calculated (Equation 1). Where angle φ_1 corresponds to a larger proportion; angle φ_2 corresponds to a smaller fraction; n_1 is the number of observations in the first sample (experimental groups); n_2 is the number of observations in the second sample (control groups).

In the case (Equation 2) crucial importance $\varphi*_{kr}$ that corresponds to the levels of statistical significance accepted in psychological and pedagogical research is equal (Equation 3). Thus, there is inequality $\varphi*_{emp} = 0.64 < \varphi*_{kr} = 1.64$. That is, the empirical value is in the zone of insignificance and the hypothesis H0 is accepted. This means that reliably, with a significance level of α = 0.05, the student performance indicator of the experimental group according to the results of the semester exam in the discipline "General chemistry" does not differ from the student learning quality indicator of the control group.

As the results of statistical data processing confirm, the differences between the control and experimental groups are insignificant, which allows us to verify the effectiveness of the OER methodology using the example of CHOHOC discipline. Let us now check the reliability of the hypothesis that there is no, from a statistical point of view, differences between the student achievement levels of the experimental and control groups from the CHOHOC course (Table 10). Hypotheses will be formulated: H0: The percentage of students passed the semester exam in "Chemistry of higher organic compounds" with grade “excellent” or “good” in the experimental group is no more than in the control group; H1: The proportion of students who passed the semester exam in "Chemistry of higher organic compounds" with grade “excellent” or “good” in the experimental group is greater than in the control group.

A table of empirical frequencies according to two values of the attribute: students who got grades "5" or "4", and students who received grades "3" or "2" (Table 11) is constructed. According to the corresponding table, the value of the cell size corresponding to the shares of 89.4% and 96.3% in the corresponding groups is determined:

$$\varphi_1(96.3\%) = 2.754$$

$$\varphi_2(89.4\%) = 2.478$$

Then the empirical definition φ* is calculated (Equation 4). Thus, there is inequality $\varphi*_{emp} = 1.51 < \varphi*_{kr} = 1.64$. It means that the empirical definition value $\varphi*_{emp} = 1.51$ is in the zone of insignificance and the hypothesis H0 is accepted. This means that the success level of students from the experimental group is higher than the success level of students from the control group.

Let us verify the reliability of the hypothesis of the absence, from a statistical point of view, of differences between the quality levels of student performance in control and experimental groups in the discipline "Chemistry of higher organic compounds" (Figure 5). Hypotheses are formulated: H0: The percentage of students passed the semester exam in "Chemistry of higher organic compounds" with grade “excellent” or “good” in the experimental group is no more than in the control group; H1: The proportion of students who passed the semester exam in "Chemistry of higher organic compounds" with grade “excellent” or “good” in the experimental group is greater than in the control group.

A table of empirical frequencies according to two values of the attribute: students who got grades "5" or "4" and students who received grades "3" or "2" (Table 12) is constructed. According to the corresponding table, the values of the cell size correspond to the shares of 42.4% and 66.7% in the corresponding groups:

$$\varphi_1(66.7\%) = 1.911$$

$$\varphi_2(33.3\%) = 1.418$$

Then the empirical definition φ* is calculated (Equation 5). Thus, there is inequality $\varphi*_{emp} = 2.68 > \varphi*_{kr} = 2.31$. That is, empirical significance $\varphi*_{emp} = 2.68$ is in the zone of significance and the hypothesis H1 is accepted, but hypothesis H0 is not accepted. This means that reliably the student success quality indicator of the experimental group according to the results of semester control in the discipline “Chemistry of higher organic compounds” with a significance level ∝=0.01, from a statistical point of view, differs significantly from the student quality indicator of the control group. The results of statistical processing of semester control data on the “Chemistry of higher organic compounds” discipline showed the effectiveness of the developed methodology for using OER, which contributed to improving the quality of student performance in the discipline “Chemistry of higher organic compounds”.

5. CONCLUSIONS:

Summing up the study, it is to be noted that the open educational resources can give free access to education for everyone, but mainly for non-traditional groups of students, expanding opportunities for higher education. Open educational resources are by no means an alternative to classical education. This is only a means to obtain versatile, deep, professional information.

Open educational resources were examined and it was determined that it is impossible to use these open sources only as additional forms of education. Modern forms of using network resources for educational purposes are largely limited only by their consideration as a consequence of an auxiliary resource for traditional classroom education. Our analysis showed that any educational resources inherently can exist only if combined with the information environment that every educational institution should have. In this regard, open educational resources can be used as an element of traditional learning.

The hypothesis of the study on the example of three subjects was examined, it determined the possibility of monitoring the quality of teaching. Subjects – “Organic Chemistry” (OCH) in the 2nd year, “Analytical Chemistry” (ACH) in the 3rd year, “Physicochemical Analysis Methods” (PCHAM) in the 3rd year. For each discipline, the shares of students were identified who, according to the results of the semester exam in the discipline, have positive marks and compared the indicators in experimental and in control groups. An analysis of all distributions and statistical processing showed that the assumption of which group of students got better after using the developed methodology showed that the hypotheses were set correctly and, on the whole, the results of the experimental group were 20-30% higher than that of the control group. Therefore, it can be said that the analysis of the indicators of introducing open educational resources has shown that the introduction of the chemical-technological cycle into the process of teaching disciplines is generally 20-30% more successful than using only its own or traditional methods and methods of circumcision. Such an advantage is expressed not only in an increase in quantitative indicators of grades but also subject to the development of competencies of the students themselves.

An additional condition that was not fully shown in the work was the formation of an understanding that, in addition to quantitative assessment, it is worth talking about the qualitative execution of the proposed project. In a qualitative way, the use of OER will contribute to the formation of a higher level of performance and professional fitness in general. The application of the proposed methodology for the use of OER contributed for improving the quality of academic performance of students in the Department of chemical technology, which makes it possible to conclude that the hypothesis of the study is confirmed in terms of increasing the level of professional training of future specialists in the Department of chemical technology.

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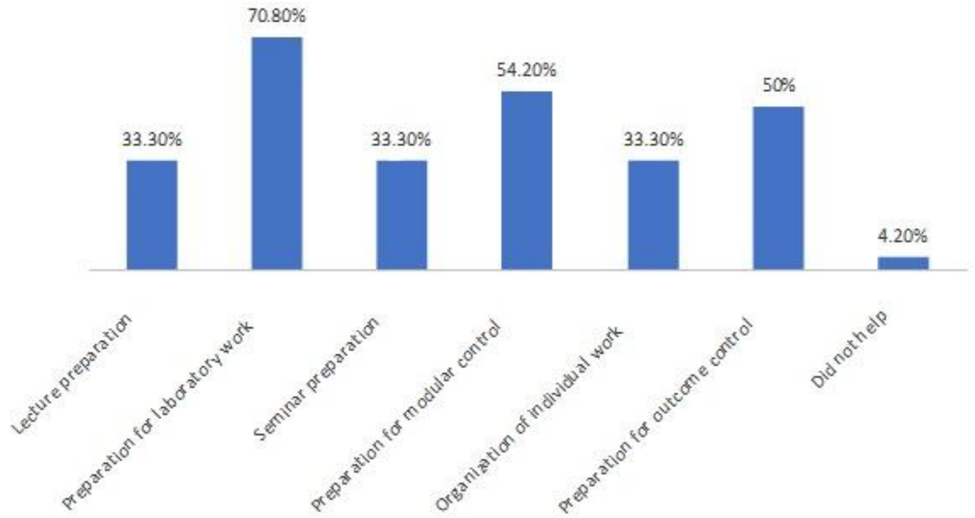

Figure 1. *Diagram of distribution of students' responses on survey results in OER*

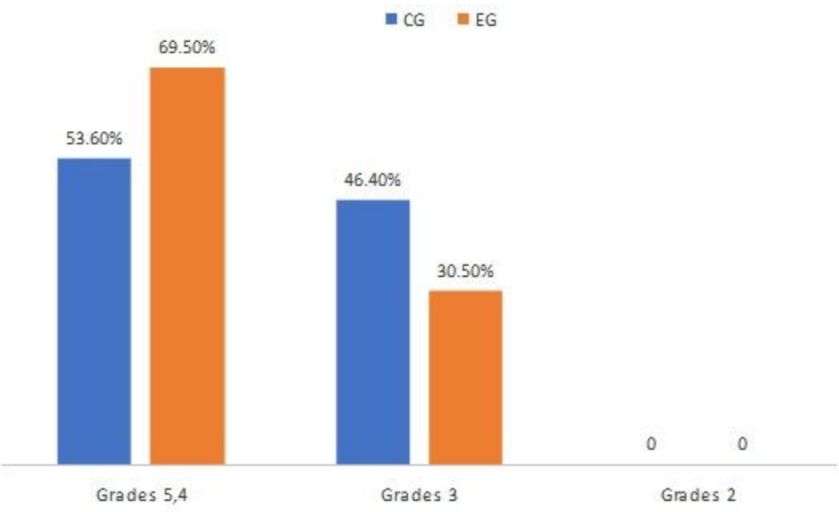

Figure 2. *Diagram of student’s academic standing in KG and EG on discipline "Organic chemistry"*

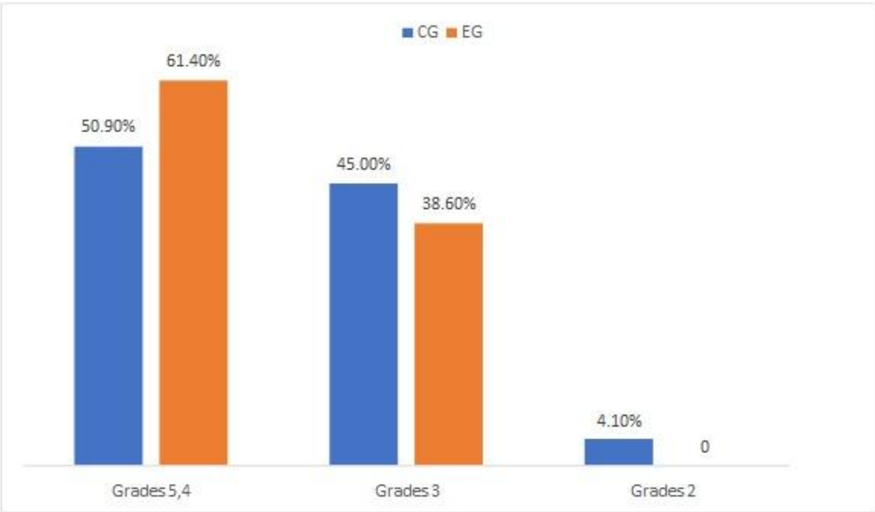

Figure 3. *Diagram of students’ academic standing in KG and EG on discipline "Analytical chemistry"*

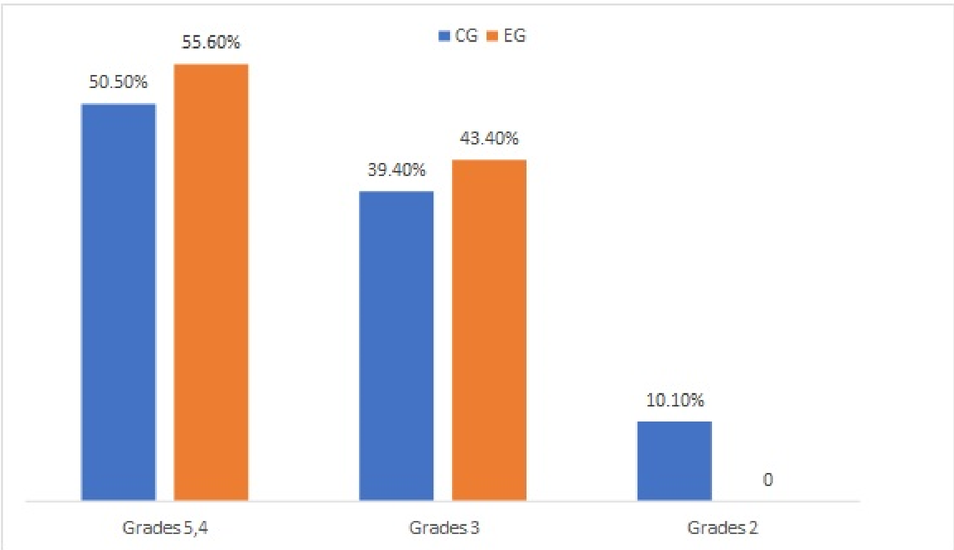

Figure 4. *Diagram of student’s academic standing in KG and EG on discipline "Physical and chemical methods of analysis"*

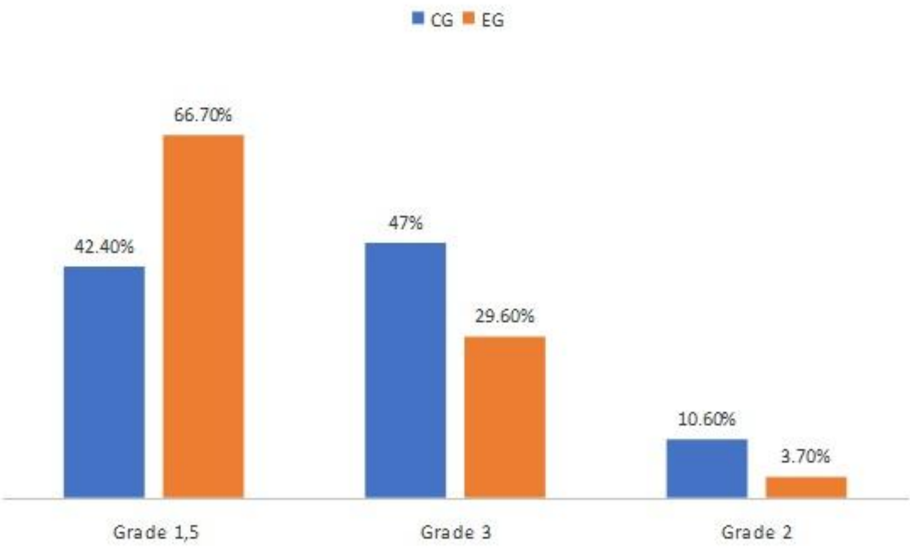

Figure 5. *Diagram of success level of students from CG and EG in the discipline "Chemistry of higher organic compounds"*

Table 1. *Distribution of semester exam scores on the discipline "Chemistry of higher organic compounds" in 2012-2014*

Years of study	Group	Headcount	Number of students assessed				Percentage of students assessed			
			2	3	4	5	2	3	4	5
2012-2013	KT-801	17	1	9	5	2	5.9%	52.9%	29.4%	11.8%
	PR-802	18	5	9	3	1	27.8%	50%	16.7%	5.5%
	Total	35	6	18	8	3				
2013-2014	KT-901	18	0	10	6	2	0.0%	55.6%	33.3%	11.1%
	PR-902	13	1	3	7	2	7.7%	23.1%	53.8%	15.4%
	Total	31	1	13	13	4				

Table 2. *Summary table of student assessment and quality of student assessment in control groups*

Group	Academic performance	Of successful students
KT-801	94.1%	41.2%
PR-802	71.5%	22.2%
KT-901	100%	44.4%
PR-902	92.3%	69.2%

Table 3. *Scheme of the formation of control and experimental groups at the forming stage of the pedagogical experiment in the CHOHOC discipline*

Groups	Number of students (by the academic years)				Total
	2012-2013	2013-2014	2014-2015	2015-2016	
Control	35	31			66
Experimental			36	18	54
Total:	35	31	36	18	120

Table 4. *Distribution of semester exam grades on "General chemistry" of 2012-2014 in control group*

Group	**Number of students**	**Grade**	**Distribution of grades**			
			2012-2013		**2013-2014**	
			Number of students were assessed	**Share of students were assessed, %**	**Number of students were assessed**	**Share of students were assessed, %**
KT	35	"2"	0	0	0	0
		"3"	8	47	12	66.7
		"4"	7	41.2	4	22.2
		"5"	2	11.8	2	11.1
PR	31	"2"	3	16.7	1	7.7
		"3"	12	66.7	8	61.5
		"4"	1	5.5	2	15.4
		"5"	2	11.1	2	15.4

Table 5. *Distribution of semester exam grades on "General chemistry" of 2014-2015 in experimental group*

Group	**Number of students**	**Grade**	**Distribution of grades**			
			2012-2013		**2013-2014**	
			Number of students were assessed	**Share of students were assessed, %**	**Number of students were assessed**	**Share of students were assessed, %**
KT	35	"2"	0	0	0	0
		"3"	13	72.2	1	11.1
		"4"	2	11.1	8	88.9
		"5"	3	16.7	0	0
PR	31	"2"	2	11.1	1	11.1
		"3"	10	55.6	6	66.7
		"4"	4	22.2	1	11.1
		"5"	2	11.1	1	11.1

Table 6. *Distribution of semester exam grades on "General chemistry" of 2014-2015 in control and experimental groups*

Group	**Number of students**	**Grade**	**Distribution of grades**	
			Number of students were assessed	**Share of students were assessed, %**
CG	66	"2"	4	6.1
		"3"	40	60.6
		"4"	14	21.2
		"5"	8	12.1
EG	54	"2"	3	5.5
		"3"	30	55.6
		"4"	15	27.8
		"5"	6	11.1

Table 7. *Table for calculations by Fisher's criterion when comparing two groups by the proportion of students with rating "5" or "4" and "3" or "2"*

Group	Grades 4 or 5		Grades 3 or 2		Total
	Number of students	%	Number of students	%	
CG	22	33.3	44	66.7	66
EG	21	38.9	33	61.1	54
Total	43		77		120

Table 8. *Level of achievement of students in discipline "General chemistry"*

Group	Success	Number of students assessed	Average grade
CG	93.9	33.3	3.4
EG	94.5	38.9	3.4

Table 9. *Distribution of semester exam grades on "Chemistry of higher organic compounds" discipline of 2014-2015 in experimental groups*

Group	Staff strength	Number of students assessed				Share of students assessed, %			
		2	3	4	5	2	3	4	5
KT-101	18	0	5	10	3	0.0%	27.8%	55.6%	16.6%
PR-102	18	1	3	11	3	5.5%	16.7%	61.1%	16.7%

Table 10. *Distribution of semester exam grades on "Chemistry of higher organic compounds" discipline of 2014-2015 in experimental groups*

Group	Staff strength	Number of students assessed				Share of students assessed, %			
		2	3	4	5	2	3	4	5
KT-111	9	0	4	5	0	0.0%	44.4%	55.6%	0.0%
PR-112	9	1	4	3	1	11.1%	44.4%	33.3%	11.1%

Table 11. *Table for calculations by Fisher's criterion when comparing two groups by the proportion of students with positive ratings on the final control at discipline "Chemistry of higher organic compounds"*

Group	Grades 3-5		Grade 2		Total
	Number of students	%	Number of students	%	
CG	59	89.4	7	10.6	66
EG	52	96.3	2	3.7	54
Total	111		9		120

Table 12. Table for calculations by Fisher's criterion when comparing two groups by the proportion of students with ratings "5" or "4" and "3" or "2" on the final control at discipline «Chemistry of higher organic compounds"

Group	Grades 3-5		Grade 2		Total
	Number of students	%	Number of students	%	
CG	28	42.4	38	57.6	66
EG	36	66.7	18	33.3	54
Total	64		56		120

$$\varphi^* = (\varphi_1 - \varphi_2)\sqrt{\frac{n_1 n_2}{n_1 + n_2}} \quad \text{(Eq. 1)}$$

$$\varphi^*_{emp} = (1.347 - 1.230)\sqrt{\frac{54 * 66}{54 + 66}} \approx 0.64 \quad \text{(Eq. 2)}$$

$$\varphi^*_{kr} = \begin{cases} 1.64 (p \leq 0.05) \\ 2.31 (p \leq 0.01) \end{cases} \quad \text{(Eq. 3)}$$

$$\varphi^*_{emp} = (2.754 - 2.478)\sqrt{\frac{52 * 59}{52 + 59}} \approx 1.51 \quad \text{(Eq. 4)}$$

$$\varphi^*_{emp} = (1.911 - 1.418)\sqrt{\frac{54 * 66}{54 + 66}} \approx 2.68 \quad \text{(Eq. 5)}$$