Educational Technology Quarterly, Vol. **2021**, Iss. 3, pp. 388-401 https://doi.org/10.55056/etq.26

Formation of digital competence of CS bachelors in the use of cloud-based learning environments

Tetiana A. Vakaliuk[1,2,3], *Oleg M.* Spirin[4,2] and *Valerii V.* Kontsedailo[5]

[1]*Zhytomyr Polytechnic State University, 103 Chudnivsyka Str., Zhytomyr, 10005, Ukraine*
[2]*Institute for Digitalisation of Education of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine*
[3]*Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine*
[4]*University of Educational Management, 52A Sichovykh Striltsiv Str., Kyiv, 04053, Ukraine*
[5]*Inner Circle, Nieuwendijk 40, 1012 MB Amsterdam, Netherlands*

Abstract. The article clarifies the concept of digital competence of CS bachelors in the use of cloud-based learning environments. The criteria (value-motivational, cognitive, operational-activity, research, didactic), indicators, and levels (low, medium, sufficient, high) of the formation of digital competence of CS bachelors in the use of cloud-based learning environments (CBLE) are specified. The results of the pedagogical experiment were analyzed, demonstrating an increased level of digital competence formation of CS bachelors in the use of CBLE, and thus the pedagogical efficiency of adopting the methodical system of using CBLE in the training of CS bachelors.

Keywords: competence, digital competence, cloud-based learning environment, CS bachelors

1. Introduction

In recent years, there has been a substantial growth in interest in educational technology, both from educational organizations and from economic and governmental structures. Simultaneously, the use of cloud technologies to provide individuals with quality education and an opportunity to improve their life is being intensively investigated. New digital technologies have a considerable impact on the educational process in educational institutions, education in general, and its financial and distant accessibility.

Because of the expanding popularity of cloud technology, there are numerous opportunities for all educational institutions to manage the educational process. One of the primary concerns of higher education institution (HEI) management is raising the level of educational and methodological work at a specific educational institution.

The issue of developing highly trained experts in a variety of professions, including bachelors in computer science (CS), is becoming more significant under the circumstances of digital

tetianavakaliuk@gmail.com (T. A. Vakaliuk); oleg.spirin@gmail.com (O. M. Spirin);
valerakontsedailo@gmail.com (V. V. Kontsedailo)
https://sites.google.com/view/neota/profile-vakaliuk-t (T. A. Vakaliuk);
http://umo.edu.ua/en/university/leadership/spirin-olegh-mikhajlovich (O. M. Spirin);
https://www.linkedin.com/in/kontsedailo/ (V. V. Kontsedailo)
0000-0001-6825-4697 (T. A. Vakaliuk); 0000-0002-9594-6602 (O. M. Spirin); 0000-0003-2240-7891
(V. V. Kontsedailo)

transforming the higher education system. The efficient collaboration of all educational topics, possibly with the aid of cloud technology, is crucial to the professional training of CS bachelors.

As a result, the issue of the multi-level formation of digital competence of CS bachelors in the use of cloud-based learning environments (CBLE) has become actual in the context of the introduction of a cloud-based learning environment (CBLE) into the educational process of training CS bachelors.

According to Ukraine's "Law on Higher Education", competence is "a dynamic combination of knowledge, skills, and practical skills, ways of thinking, professional, ideological, and civic qualities, and moral values, which determines the ability of an individual to successfully carry out professional and further learning activities" [5]. The definition of competence is also included in the National Qualifications Framework, which defines it as "the ability of an individual to do a given type of activity, expressed through knowledge, understanding, skills, values, and other personal attributes" [10].

The continuous advancement of information and communication technologies leads to the continuous refinement of the concept of "digital competence".

Gurzhiy and Ovcharuk [2] argue, in particular, that "digital competence" "should be understood as a proven ability to work individually or collectively, using tools, resources, processes, and systems responsible for accessing and evaluating information obtained through any media resources, and using such information to solve problems, communicate, create informed solutions, products, and systems, as well as to gain new knowledge".

As noted by Spirin [17], digital competence is "a confirmed ability of an individual to use information and communication technologies in practice to meet their individual needs and solve socially significant, in particular, professional problems in a particular subject area". Morze and Kocharian [9] also agree with this opinion.

Ovcharuk [11] adds her voice to that of earlier researchers and offers the following basic definition: "the demonstrated ability of an individual to use information and communication technologies in practice to meet their own demands and resolve socially significant ones, in particular, professional tasks in a particular subject area or type of activity" is known as "digital competence".

Degtyaryova [1] recognizes a subject teacher digital competence as a crucial facet of professional teacher competence. Lytvynova [7] defines subject teacher digital competence as "the ability of the teacher to use ICT in practice in the information and educational environment, guided by professional, personal, and social demands".

Spirin and Ovcharuk [18, p. 46-48] identified the IC competence (digital competence) components shown in figure 1.

In contrast to the conventional method of identifying the components of digital competence, Zakhar [23, p. 23-24] notes the following: components of worldview, technology, organizational methodology, and self-education

According to Ivanova [3, p. 176] and Kocharyan [4, p. 68], digital competence is composed of the following components: value-motivational (needs, goals, and motivations); cognitive (knowledge); operational-activity (ability, skills to use knowledge acquired with ICT); and research.

The article's *goals* are to define the concept "digital competence of CS bachelors in the use of CBLE", identify the factors that contribute to its development, and conduct an experimental

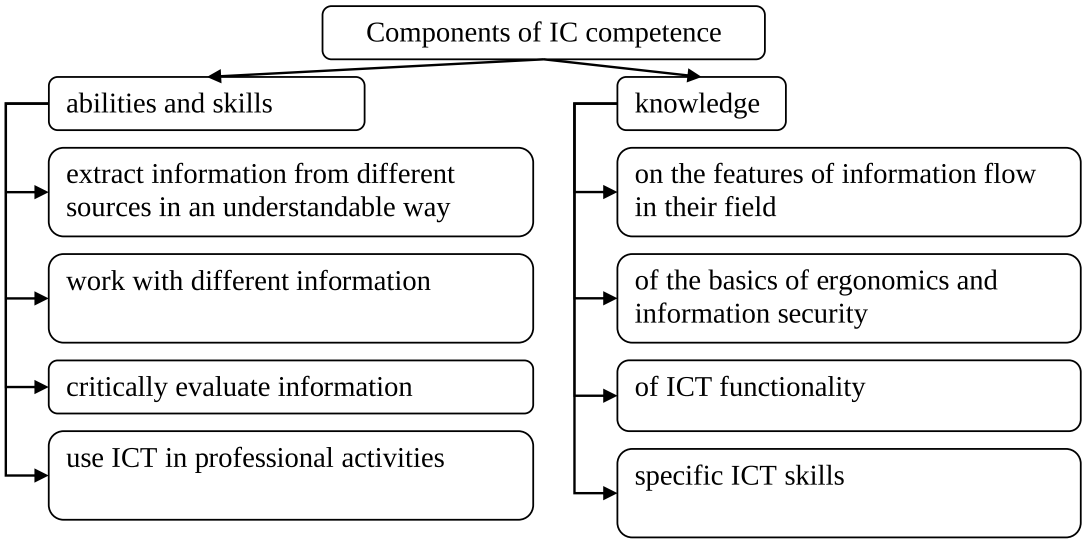

Figure 1: Components of IC (digital) competence according to Spirin and Ovcharuk [18].

evaluation of the efficacy of the suggested structures, procedures, and resources for using a cloud-based learning environment in the instruction of computer science bachelors.

2. Method

The digital competence of CS bachelors should differ significantly from the digital competence of graduates of other specialties in the subject area, as should the depth and volume of knowledge, skills, and abilities in the field of information and communication technologies, particularly in the use of cloud technologies.

As a result, we define the *digital competence of CS bachelors in the use of CBLE as the ability of an individual confirmed in practice based on the acquired knowledge, skills, and abilities in cloud technologies and solving professional problems in the field of CS and IT*, summarizing all the approaches to the interpretation of this concept that are currently available.

According to Lytvynova [7], Shyshkina [15], more electives and/or specialized courses should be offered to students in order to raise their level of digital competence during the educational process. In light of this, the following modifications to bachelor of computer science instruction are suggested:

- CBLE for CS bachelors was created [19].
- Cloud-based learning tools that are appropriate for use in the instruction of CS bachelors were chosen [20].
- For the purpose of using CBLE to study a variety of topics in disciplines directly relevant to programming ("Programming", "Java programming", "Web programming", "Programming technologies", "Selected issues of computer engineering"), the content of those disciplines has been updated.

- Forms, methods, and tools of using CBLE in the CS bachelors training are developed and implemented.
- The development and implementation of an elective course on "Cloud technologies in education" allows CS bachelors to become familiar with the peculiarities of using various cloud technologies as they enhance their digital competence in the use of CBLE.

The learning objectives of the elective course "Cloud technologies in education" are to become familiar with the main methodologies of cloud technologies in education, a general review of the cloud technologies that are currently available, and consideration of the main cloud technology provisions for use in the educational process of the HEI, which should ensure the formation of digital competence of CS bachelors in the use of CBLE.

The following are the specific learning goals for the elective course "Cloud technologies in education":

- to ensure that CS bachelors develop a conscious and responsible attitude toward the theoretical and practical foundations of the use of cloud technologies in education;
- to gain knowledge and skills in the application of cloud technologies in education;
- familiarization of CS bachelors with cloud services for educational purposes;
- to gain knowledge and skills in the development applications for cloud services;
- formation of digital competence in the use of CBLE.

The topics for instructional and content modules have been prepared based on the goals and objectives of teaching cloud technologies in education.

Module 1: The history of cloud computing

- *Content module 1.* The evolution of cloud computing. Cloud computing. Cloud computing technologies. Cloud computing services. Leading providers of cloud services.
- *Content module 2.* Experience with cloud technology. Experience using cloud technology in education.

Module 2: Cloud services

- *Content module 3.* Cloud services as an alternative to office applications. Cloud services for collaborative document creation. Presentations can be created using cloud services. Cloud-based survey creation services.
- *Content module 4.* Cloud storage as a disk replacement.

Module 3: Cloud-based learning environment

- *Content module 5.* Experience in CBLE implementation.
- *Content module 6.* The CBLE design. Tools for putting together a cloud-based learning environment. CBLE specifications and design features. CBLE content and design methodologies.

The author's methodology of using CBLE for CS bachelors [19, 21] allows the teacher to freely choose the forms, methods, and necessary tools for the learning process [14].

It should be mentioned that a competency-based approach should be implemented when conducting classes. A competency-based approach to teaching informatics teachers should provide for the formation and acquisition of relevant competencies [13]. Therefore, it should be considered that all aspects of the educational process should be concentrated on helping students acquire the skills required for professional activities, particularly digital competencies [6, p. 11].

Advanced training is another option to raise the level of digital competency of HEI students and teachers [23, p. 28]. A professional development program titled "Information and communication technologies in full-time (blended) learning" is suggested by Mintiy, Kharadzjan and Shokaliuk [8]. The course participants should master the basics of the theory and practice of designing digital educational resources [8]. Conducting master classes, training, etc. is another technique to improve the digital competence using CBLE, as noted in [7, 15]. Therefore, additional course on utilizing cloud technology in education was given for university instructors and students as part of this study [22].

An example of a training session.

Topic: Using Google Classroom.
Goal: Acquire knowledge and skills of how to design courses using Google Classroom.

1. Create your course.
2. Add 3-4 to the course.
3. Create a number of different assignments and provide them to all students in the course for completion: downloading training materials, taking a poll, completing an answer-attachment assignment, etc.
4. Make an evaluation of the work that has been done.

In such training sessions, the instructor first demonstrates the subject using an example of finishing the assignment, and then the students finish the task independently, if necessary, with the instructor's guidance.

In to assess the level of digital competence of CS bachelors in the use of CBLE, it is critical to determine the criteria and indicators that contribute to that formation.

In line with the findings of Kocharyan [4], Spirin and Ovcharuk [18], Zakhar [23], we highlight the following criteria and associated indicators for the formation of digital competence of CS bachelors in the use of CBLE:

1. *Value-motivational* – reasons, objectives, and requirements for using cloud technologies in professional settings:
   - motivation to use a cloud-based learning management system in the educational process.
   - motivation to use cloud-based learning tools in the educational process.
   - motivation for leveraging cloud services for self-learning.
2. *Cognitive* – understanding of cloud technologies in relation to using CBLE:

- to demonstrate knowledge of cloud technologies.
- to comprehend what a cloud-based learning environment's fundamental elements are.
- to demonstrate knowledge of cloud-based learning tools.

3. *Operational and activity* – the skills to operate the acquired knowledge on cloud technologies in relation to using CBLE:
   - using cloud-based mind maps for educational purposes.
   - using cloud-based compilers.
   - using cloud technologies to evaluate programming skills.
   - using cloud-based learning management system (cloud-based LMS).
   - using massive open online courses (MOOC).
   - using cloud-based tools to collaborate on a project.
4. *Research* – knowledge and skills in using cloud technology to facilitate scientific research:
   - when composing term papers and theses, to choose and use a variety of cloud-based tools.
   - when working on a group project, to choose and use a variety of cloud-based tools.
   - to apply the CBLE's cooperative tools.
5. *Didactic* – the ability to use CBLE for learning activities and cooperation:
   - to use a cloud-based LMS.
   - to deliver instructional content using cloud-based tools.
   - to use cloud-based communication tools.
   - to use cloud-based knowledge assessment tools.

According to the formulated criteria and indicators, the levels of formation of digital competence of CS bachelors in the use of CBLE and the characteristics of each of them, are presented in table 1.

3. Results and discussion

A pedagogical experiment was carried out to test the hypothesis that training CS bachelors in a specially created CBLE will assist in the growth of their digital competence.

170 students were involved in the experiment. The following factors were taken into account:

1. If possible, the same instructor trained both the experimental group and the control group.
2. The experimental group's initial level of formation of digital competence in the use of CBLE is statistically equivalent to that of the control group's [21].
3. The experimental group completed CBLE training whereas the control group was taught training in the classical way.

Table 1
Description of the levels of digital competence of CS bachelors in the use of CBLE.

Criterion	Level	Description
Value-motivational	low	does not recognize the value of CBLE, a cloud-based LMS, and cloud-based learning technologies
	average	understanding the role of cloud technologies in professional activities
	sufficient	knowing that cloud technologies (CBLE and cloud-based LMS, cloud-based learning tools in particular) must be used in the educational process
	high	a desire to incorporate the CBLE into the educational process
Cognitive	low	Reimagine the knowledge gained about cloud technology with the help of an instructor. Knows the key elements of CBLE and, with a teacher's assistance, can describe them. Has basic knowledge of cloud-based learning tools.
	average	Understanding and explaining the knowledge of cloud technologies. Recognize and describe the primary CBLE components. Describe well-known cloud-based learning tools.
	sufficient	can put learned expertise in cloud technology to use
	high	able to study independently at CBLE.
Operational and activity	low	according to the sample, CBLE, cloud-based LMS, and cloud-based learning tools can be used to complete tasks
	average	knows how to use CBLE, cloud LMS, and cloud learning tools to complete a task, and can describe the benefits of doing so
	sufficient	completes tasks independently in CBLE using cloud-based LMS and cloud-based learning tools
	high	is able to use cloud technology effectively for both professional and personal development
Research	low	can use cloud-based tools for research work and collaborative projects on a sample basis
	average	understands how to use CBLE, cloud-based LMS, and cloud-based collaboration tools for research and/or collaborative projects, and can describe how to use various cloud-based tools
	sufficient	independently completes research tasks and a team project in CBLE while using cloud-based LMS and learning tools
	high	has the skills to select cloud-based learning tools to successfully complete research and collaborative projects
Didactic	low	has the skills required to operate in CBLE using a variety of learning tools
	average	has the skills required to use the primary CBLE learning tools
	sufficient	has the skills required to use the majority of the CBLE learning tools
	high	has the skills required to use the all of the CBLE learning tools

A survey of students was used to measure the level of development of the digital competence of CS bachelors in the use of CBLE in the control and experimental groups in order to establish statistical equivalence.

It could be stated that the majority of students have an average level of formation of all criteria for digital competence of CS bachelors in the use of CBLE based on the findings of a survey of students at this stage. According to the findings of the survey conducted prior to the experiment, let's see if there are any variations in the levels of formation of students' digital competence of CS bachelors in the use of CBLE in the control group and the experimental group (table 2).

Table 2
Levels of formation of digital competence of CS bachelors in the use of CBLE in control (CG) and experimental (EG) groups (before the experiment).

Criterion	Low		Average		Sufficient		High	
	CG	EG	CG	EG	CG	EG	CG	EG
Value-motivational	18	17	48	46	13	16	6	6
Cognitive	20	18	43	45	16	16	6	6
Operational and activity	20	19	44	44	15	16	6	6
Research	20	18	44	45	15	15	6	7
Didactic	18	18	46	45	16	16	5	6

Null hypothesis H_0: in the experimental group and the control group, there are no statistically significant variations in the distributions of the level of formation of digital competence of CS bachelors in the use of CBLE .

Alternative hypothesis H_a: there are statistically significant changes in the distributions of digital competence of CS bachelors in the use of CBLE between the experimental group and the control group.

The samples are independent, and the property being measured (formation of digital competence of CS bachelors in the use of CBLE by each of the criteria) is given on a scale with the following values: "low", "average", "sufficient", "high".

We utilize Pearson's χ^2 test [12] to determine whether the experimental group and control group are statistically equivalent. Some assumptions are crucial for this criterion [16]:

- sample size $n \geq 30$;
- expected cell counts should not be less than 5; the selected digits exhaust the entire distribution, that is, they cover the entire range of feature variability.

For the samples that were acquired, all of these suppositions are true. So, we have the right to use this test.

Therefore, to test the hypothesis, we will find the value of χ^2_{emp}, given that the experimental data are presented in the form of table $2 \times C$, where $C = 4$ is the number of categories:

$$\chi^2_{emp} = \frac{1}{n_1 n_2} \sum_{i=1}^{n} \frac{(n_1 Q_{2i} - n_2 Q_{1i})^2}{Q_{1i} + Q_{2i}}, \tag{1}$$

where

n_1 is the number of students in the control group;

n_2 is the number of students in the experimental group;

$Q_{1i}(i = 1, 2, 3, 4)$ is the number of students in the control group who received grades in accordance with the levels "low", "average", "sufficient", "high";

$Q_{2i}(i = 1, 2, 3, 4)$ – the number of students in the experimental group who received grades in accordance with the levels “low”, “average”, “sufficient”, “high”.

For the test, the number of degrees of freedom calculated by the formula $df = C - k - 1$, where C is the number of categories in the sample, k is the number of imposed independent conditions [12, p. 636]. Therefore, $df = 1$.

The results of calculating the statistics of these samples are presented in table **??**. From table IX [16, p. 328], the critical value of χ^2 for the significance level $\alpha = 0.05$ and the number of degrees of freedom $df = 1$ is $\chi^2_{\alpha=0.05} = 3.84$, and for $\alpha = 0.01$ is $\chi^2_{\alpha=0.01} = 6.64$. Let’s build the significance axis for the obtained data (figure 2).

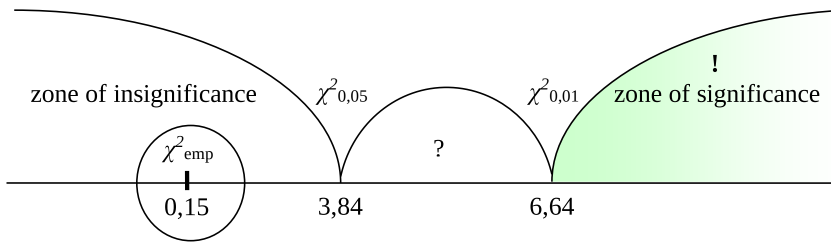

Figure 2: The Pearson’s $chi2$ test’s significant axis for the cognitive criterion (before the experiment).

We calculate χ^2_{emp} for each of the criteria:

- for the cognitive criterion $\chi^2_{emp} = 0.15$;
- for the operational and activity criterion $\chi^2_{emp} = 0.05$;
- for value-motivational criterion $\chi^2_{emp} = 0.38$;
- for research criterion $\chi^2_{emp} = 0.19$;
- for didactic criterion $\chi^2_{emp} = 0.10$.

The null hypothesis H_0 can be accepted if $\chi^2_{emp} < \chi^2_{\alpha=0.05}$ for each of the criteria, which allows us to claim that these samples did not have statistically significant differences by all criteria before the experiment, according to the significance axis (figure 2). We may therefore say that the experimental group and control group had roughly equal conditions and that the individuals in both groups were composed similarly.

After the initial survey in the control group and the experimental group, students were trained in programming in accordance with the CS curriculum. After the experiment was complete, the level of formation of digital competence of CS bachelors in the use of CBLE for each student was individually assessed by the teacher, and as a result, an average score was set for various assessments. The students were then given a new questionnaire.

Table 3 provides the generalized quantitative results of determining the level of formation of digital competence of CS bachelors in the use of CBLE in accordance with all criteria.

Comparative distribution of control group and experimental group before and after the experiment by all criteria is shown in table 4 and figure 3.

Table 4 and figure 3 in particular demonstrate that more students from the experimental group — as compared to fewer students in the control group — developed a high and sufficient

Table 3
Levels of formation of digital competence of CS bachelors in the use of CBLE in control (CG) and experimental (EG) groups (after the experiment).

Criterion	Low		Average		Sufficient		High	
	CG	EG	CG	EG	CG	EG	CG	EG
Value-motivational	10	9	46	25	22	31	7	20
Cognitive	10	9	43	24	24	34	8	18
Operational and activity	10	9	43	25	25	33	7	18
Research	11	9	43	25	24	32	7	19
Didactic	10	9	44	23	25	36	6	17

Table 4
Levels of formation of digital competence of CS bachelors in the use of CBLE in control (CG) and experimental (EG) groups (before and after the experiment).

Level	Value-motivational				Cognitive				Operational and activity				Research				Didactic			
	before		after		before		after		before		after		before		after		before		after	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
Low	18	17	10	9	20	18	10	9	20	19	10	9	20	18	11	9	18	18	10	9
Average	48	46	46	25	43	45	43	24	44	44	43	25	44	45	43	25	46	45	44	23
Sufficient	13	16	22	31	16	16	24	34	15	16	25	33	15	15	24	32	16	16	25	36
High	6	6	7	20	6	6	8	18	6	6	7	18	6	7	7	19	5	6	6	17

level of digital competence in using CBLE for each criterion as a result of the application of the experimental methodological system for training CS bachelors:

- value-motivational criterion: at a sufficient level in the experimental group from 16 to 31, in the control group from 13 to 22; at a high level in the experimental group from 6 to 20, in the control group from 6 to 7;
- cognitive criterion: at a sufficient level in the experimental group from 16 to 34, in the control group from 16 to 24; at a high level in the experimental group from 6 to 18, in the control group from 6 to 8;
- operational and activity criterion: at a sufficient level in the experimental group from 16 to 33, in the control group from 15 to 25; at a high level in the experimental group from 6 to 18, in the control group from 6 to 7;
- research criterion: at a sufficient level in the experimental group from 15 to 32, in the control group from 15 to 24; at a high level in the experimental group from 7 to 19, in the control group from 6 to 7;
- didactic criterion: at a sufficient level in the experimental group from 16 to 36, in the control group from 16 to 25; at a high level in the experimental group from 6 to 17, in control group from 5 to 6.

Therefore, we can draw the conclusion that using a CBLE during the training of CS bachelors has a significant positive effect on the rise in the proportion of students in the experimental

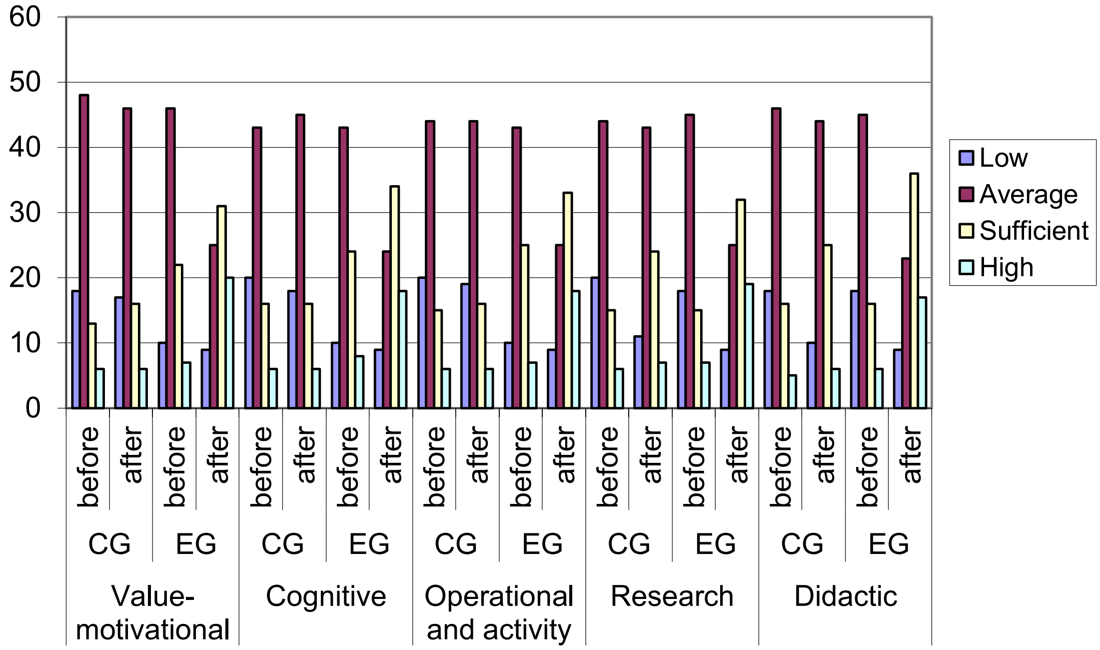

Figure 3: Comparative distribution of students according to the levels of formation of digital competence of CS bachelors in the use of CBLE in control (CG) and experimental (EG) groups (before and after the experiment).

group who have formed high and sufficient levels of digital competence in the use of CBLE for each of the criteria.

Consequently, the statistical data testify to the positive dynamics of a sufficient and high level of formation of the digital competence of CS bachelors in the use of CBLE for each of the criteria in the experimental group. We apply the Pearson's χ^2 test once more to verify the statistical equality of the experimental group and control group following the experiment.

All conditions (see above) for the resulting samples are met. To test the hypothesis, we find the value of χ^2_{emp} for each of the criteria and construct the significance axis for the obtained data (figure 4):

- for the cognitive criterion $\chi^2_{emp} = 11.01$;
- for the operational and activity criterion $\chi^2_{emp} = 10.76$;
- for value-motivational criterion $\chi^2_{emp} = 14.05$
- for research criterion $\chi^2_{emp} = 11.64$
- for didactic criterion $\chi^2_{emp} = 13.88$.

The alternative hypothesis H_a is accepted on the basis that $\chi^2_{emp} > \chi^2_{\alpha=0.01}$ for each of the criteria. This provides justification for the claim that these samples display statistically significant differences based on all criteria, demonstrating the superior efficacy of the experimental methodological system over the traditional one.

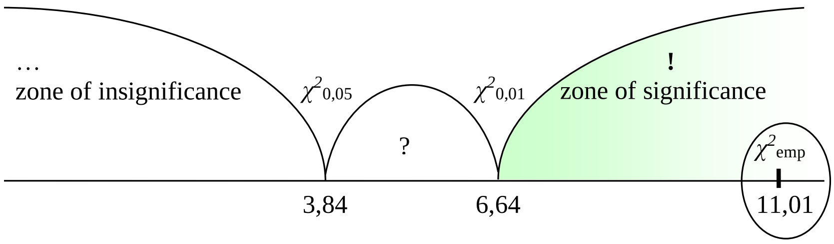

Figure 4: The Pearson's χ^2 test's significant axis for the cognitive criterion (after the experiment).

4. Conclusion

It was possible to define the concept of digital competence of CS bachelors in the use of cloud-based learning environments as the ability of an individual confirmed in practice based on the acquired knowledge, skills, and abilities in cloud technologies and solving professional problems in the field of CS and IT through the analysis and generalization of various approaches to defining the essence of the concept of digital competence. Applying the criteria (value-motivational, cognitive, operational and activity, research, and didactic), as well as relevant indicators, is advised to identify the level of formation of digital competence of CS bachelors in the use of cloud-based learning environments.

The experiment confirmed the research hypothesis that training CS bachelors in a specially created cloud-based learning environment will assist in the growth of their digital competence. The analysis of experiment results indicate an increase in the level of formation of the digital competence of CS bachelors in the use of cloud-based learning environments, and, consequently, the pedagogical expediency of introducing cloud-based forms, methods, and learning tools in the training of CS bachelors.

References

[1] Degtyaryova, G.A., 2017. *Theoretical and Methodical Basis of the Development of Information and Communication Competence of Teachers of Philological Specialties with in the Postgraduate Training System.* Thesis for the degree of Doctor of Pedagogical Sciences, specialty 13.00.04 – Theory and Methods of Professional Education (015 – Professional Education). H.S. Skovoroda Kharkiv National Pedagogical University, Kharkiv. Available from: http://hnpu.edu.ua/sites/default/files/files/2018/09/dis_Degtyaryova.pdf.

[2] Gurzhiy, A. and Ovcharuk, O., 2013. Discussion aspects of information and communication technologies competencies: Snternational approaches and Ukrainian prospcts. *Journal of Information Technologies in Education (ITE)*, (15), pp.038–043. Available from: http://ite.kspu.edu/index.php/ite/article/view/283.

[3] Ivanova, S.M., 2013. The model of the scientific workers' informational and communicational competence development in the pedagogical sciences. *Visnyk Zhytomyrskoho derzhavnoho universytetu imeni Ivana Franka*, (3 (69)), pp.171–179. Available from: http://nbuv.gov.ua/UJRN/VZhDU_2013_3_35.

[4] Kocharyan, A.B., 2016. *Developing the Information and Communication Competencies of the Humanitarian Faculty's scientific-pedagogical staff at classical universities.* Thesis for degree the Candidate of Pedagogical Sciences, specialty 13.00.10 – Information and Communication Technologies in Education. Institute of Information Technologies and Learning Tools of NAPS of Ukraine, Kyiv. Available from: https://lib.iitta.gov.ua/704491/.

[5] Law of Ukraine "On Higher Education", 2014. Available from: https://zakon.rada.gov.ua/laws/show/1556-18#Text.

[6] Lytvyn, T., 2012. The competence Approach in the Higher Educational System of Ukraine: the Analysis of Fundamental Concepts. *Pedagogic and psychology of professional education*, (2), pp.9–14. Available from: https://ena.lpnu.ua/handle/ntb/23641.

[7] Lytvynova, S.G., 2016. *Theoretical and methodological bases of designing cloud-oriented learning environment educational institution.* The dissertation for a Doctor of Pedagogical Sciences degree, specialty 13.00.10 – "Information and Communication Technologies in Education". Institute of Information Technologies and Learning Tools of NAPS of Ukraine, Kyiv. Available from: https://lib.iitta.gov.ua/166242/.

[8] Mintiy, I.S., Kharadzjan, N.A. and Shokaliuk, S.V., 2017. IC competencies development of pedagogical higher educational institutions lecturers by certification training program "Information and communication technologies in the regular-distant (combined) learning". *New computer technology*, 15, pp.240–244. Available from: https://doi.org/10.55056/nocote.v15i0.643.

[9] Morze, N.V. and Kocharian, A.B., 2014. ICT competence standards for higher educators and quality assurance in education. *Information Technologies and Learning Tools*, 43(5), p.27–39. Available from: https://doi.org/10.33407/itlt.v43i5.1132.

[10] National qualifications framework, 2011. Available from: https://zakon2.rada.gov.ua/laws/show/1341-2011-%D0%BF/paran12#n12.

[11] Ovcharuk, O.V., 2012. The development of students' information and communication competencies by means of ICT. *Information Technologies and Learning Tools*, 32(6). Available from: https://doi.org/10.33407/itlt.v32i6.757.

[12] Pearson, K. and Galton, F., 1895. VII. Note on regression and inheritance in the case of two parents. *Proceedings of the Royal Society of London*, 58(347-352), pp.240–242. Available from: https://doi.org/10.1098/rspl.1895.0041.

[13] Ponomareva, N.S., 2021. Role and place of informatics in the training of future teachers of mathematics. *Journal of Physics: Conference Series*, 1840(1), p.012035. Available from: https://doi.org/10.1088/1742-6596/1840/1/012035.

[14] Semerikov, S.O., Teplytskyi, I.O., Soloviev, V.N., Hamaniuk, V.A., Ponomareva, N.S., Kolgatin, O.H., Kolgatina, L.S., Byelyavtseva, T.V., Amelina, S.M. and Tarasenko, R.O., 2021. Methodic quest: Reinventing the system. *Journal of Physics: Conference Series*, 1840(1), p.012036. Available from: https://doi.org/10.1088/1742-6596/1840/1/012036.

[15] Shyshkina, M., 2016. *Theoretical and methodological principles of formation and development of the cloud-based educational and research environment of higher educational institution.* Thesis for the degree of the doctor of pedagogical sciences, specialty 13.00.10 - "Information and communication technologies in education". Institute of Information Technologies and learning tools of NAES of Ukraine, Kyiv. Available from: http://lib.iitta.gov.ua/166264.

[16] Sidorenko, Y.V., 2002. *Metody matematicheskoy obrabotki v psikhologii (Methods of*

mathematical processing in psychology). St. Petersburg: Rech. Available from: https://www.sgu.ru/sites/default/files/textdocsfiles/2014/02/19/sidorenko.pdf.

[17] Spirin, O.M., 2010. Information and communication and informatic competences as komponents of the system of professional-specialized competences of informatics teacher. *Information Technologies and Learning Tools*, 13(5). Available from: https://doi.org/10.33407/itlt.v13i5.183.

[18] Spirin, O.M. and Ovcharuk, O.V., 2010. Kliuchovi kharakterystyky IKT-kompetentnostei [Key characteristics of ICT competencies]. In: V.Y. Bykov, O.M. Spirin and O.V. Ovcharuk, eds. *Osnovy standartyzatsii informatsiino-komunikatsiinykh kompetentnostei v systemi osvity Ukrainy [Fundamentals of Standardization of Information and Communication Competences in the Ukrainian Education System].* Kyiv: Atika. Available from: https://lib.iitta.gov.ua/1165/.

[19] Vakaliuk, T., 2021. Structural model of a cloud-based learning environment for bachelors in software engineering. *Educational Technology Quarterly*, 2021(2), pp.257–273. Available from: https://doi.org/10.55056/etq.17.

[20] Vakaliuk, T., Spirin, O. and Kontsedailo, V., 2021. Criteria for selecting open web-oriented technologies for teaching the basics of programming to future software engineers. *Educational Technology Quarterly*, 2021(1). Available from: https://doi.org/10.55056/etq.16.

[21] Vakaliuk, T.A., 2019. *Theoretical and methodical principles of the cloud-based learning environment design and use in the training of bachelors in computer science.* The dissertation for a Doctor of Pedagogical Sciences degree, specialty 13.00.10 – "Information and Communication Technologies in Education" (011 – Educational, pedagogical science). Zhytomyr Ivan Franko State University, Zhytomyr; Institute of Information Technologies and Learning Tools of NAPS of Ukraine, Kyiv. Available from: http://lib.iitta.gov.ua/715709.

[22] Vakaliuk, T.A., Spirin, O.M., Lobanchykova, N.M., Martseva, L.A., Novitska, I.V. and Kontsedailo, V.V., 2021. Features of distance learning of cloud technologies for the organization educational process in quarantine. *Journal of Physics: Conference Series*, 1840(1), p.012051. Available from: https://doi.org/10.1088/1742-6596/1840/1/012051.

[23] Zakhar, O.H., 2015. ICT- competence of computer science teachers and ways of formation. *Open educational e-environment of modern University*, (1), pp.21–32. Available from: https://doi.org/10.28925/2414-0325.2015.1.2132.