Selection criteria for cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics

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Abstract. This article scientifically substantiates the criteria for the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics, as well as presents the results of expert evaluation of existing cloud-oriented learning technologies by defined criteria. The criteria for the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics, were determined: information-didactic, functional and technological. To implement the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics, and effective application in the process of formation of relevant competencies, the method of expert evaluation was applied. The expert evaluation was carried out in two stages: the first one selected cloud-oriented learning technologies to determine the most appropriate by author's criteria and indicators, and the second identified those cloud-oriented learning technologies that should be used in the educational process as a means to develop professional skills Bachelor of Statistics. According to the research, the most appropriate, convenient and effective cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics by the manifestation of all criteria are cloud-oriented learning technologies CoCalc and Wolfram|Alpha.

1 Introduction

The European integration processes, change, and development of the educational system of Ukraine creates new requirements for the training of specialists in almost all spheres of human life. The formation of general competencies is the basis of general education, and the formation of professional competencies of future specialists is carried out in the process of education in higher education institutions (HEI). Traditional learning is out of date and needs updating, replenished with new technologies, forms, means, and is confirmed in the text of the National Doctrine of Educational Development that "continuous improvement of the quality of education, updating its content and forms of organization of educational process; development of the system of continuous education and training throughout life; introduction of educational innovations, information technologies" [1].

An important achievement in the field of education has been the creation of open education platforms based on the implementation of the principle of the functioning of cloud technologies; comprehensive updating of training technologies, methodological support, and content of distance and e-learning based on the introduction of information and communication technologies (ICT); introduction of new forms and methods of teaching based on cloud-oriented technologies, Web 2.0 technologies, services of electronic social networks [2].

Formation of professional competencies of specialists, including the future bachelor of statistics, is carried out during the training at HEI, and the use of the latest information and communication technologies is an important key element in this process. That is why one of the leading areas of qualitative training of specialists in the requirements of today is the application of cloud technologies, and in the educational process – cloud-oriented learning technologies (COLT).

2 Analysis of recent research

Research on evaluating the effectiveness of ICT learning has largely highlighted the problem of evaluating learning outcomes.

The analysis of existing ICTs, criteria and indicators of their selection were analyzed and highlighted in the works of such scientists as V. Yu. Bykov, O. A. Galchevska, V. M. Demianenko, O. S. Golovnia, K. R. Kolos, G. P. Lavrentyeva, L. A. Luparenko, O. M. Spirin, et al.

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In particular, a team of authors (V. Yu. Bykov, O. M. Spirin, L. A. Luparenko) considered open web-oriented systems for monitoring the implementation of scientific and pedagogical research results [3]. O. S. Golovnia in her works investigated the virtualization software in the training of UNIX-like operating systems and identified the criteria and indicators of their selection [4]. V. M. Demianenko, G. P. Lavrentieva, M. P. Shyshkina give methodological recommendations on the selection and use of electronic tools and resources for educational purposes [5]. K. R. Kolos has developed criteria for selecting components of a computer-oriented educational environment for a postgraduate teacher education institution [6]. O. M. Spirin offers criteria for external evaluation of the quality of information and communication training technologies [7].

The use of cloud technologies in education has dedicated their works by such scholars as E. I. Ablialimova, O. G. Glazunova, O. V. Korotun, S. H. Lytvynova, L. M. Medzhitova, M. V. Marienko, Z. S. Seydametova, S. O. Semerikov, A. M. Striuk, S. N. Seitvelieva, Yu. V. Tryus, V. M. Franchuk, M. P. Shyshkina, and others.

In particular, the problem of developing a methodological system for the use of a cloud-oriented environment in the training of databases of future computer science teachers was investigated by O. V. Korotun [8]. The question of designing a cloud-oriented educational environment of a comprehensive educational institution by S. H. Lytvynova was also investigated [9]. Several teams of authors have considered cloud technologies in learning at different intervals [10; 11; 12; 13]. At the same time, the question of research into the use of cloud technologies in training future bachelor of statistics and the development of appropriate criteria and indicators of selection have not been sufficiently studied.

The **purpose** of the article is to define criteria and establish appropriate indicators for the selection of cloud-oriented learning technologies to shape the professional competencies of bachelors majoring in statistics.

3 Results

Research on the implementation of cloud-oriented learning technologies to shape the professional competencies of future professionals is being actively pursued by various researchers. As this research is aimed at COLT to shape the professional competencies of future Bachelor of Statistics, it is important to identify, by a certain set of criteria, the most effective, convenient and relevant cloud-oriented learning technologies to be used in the educational process of HEI.

To begin with, we will define the term “criteria”, since this definition is presented differently by different researchers.

In encyclopedic reference publications, the concept of “criterion” is defined as “a trait, a basis for evaluation, taken as a basis for classification” [14].

In “Vocational Education: A Dictionary” ed. N. G. Nychkalo, the criterion is called “the criterion for evaluating something, a means of verifying the truth or falsehood of a statement” [15].

V. N. Bahrii in his research, argues that the criterion is “a standard against which to evaluate, compare a real pedagogical phenomenon, process, or quality by reference” [16].

R. V. Torchevsky notes that “in the most general form, the criterion is an important and defining feature that characterizes the various qualitative aspects of a particular phenomenon under study, helps to clarify its essence, helps to specify the main manifestations. In this regard, the indicator is a quantitative characteristic of this phenomenon under study, which makes it possible to conclude on the state of statics and dynamics” [17].

In a short terminological dictionary I. M. Dychkivska term “criterion” is given as “an indicator that characterizes the property (quality) of an object, the evaluation of which is possible using one of the measurement methods or the expert method” [18].

Under the selection criteria of COLT for the formation of professional competencies of future bachelors of statistics, we will understand such features, qualities, and properties of cloud-oriented technologies that are required for their effective use in the educational process to form the professional competencies of future bachelors of statistics.

An expert evaluation method was used to implement the selection of the COLT for the formation of the professional competencies of future bachelors of statistics and for effective application in the process of forming the corresponding competencies. According to the purpose and objectives of the method, the corresponding COLT is numbered in ascending or descending order based on a separate trait, by which further ranking is made. It should be noted that the peer review was carried out in two stages.

In the first stage, experts were asked to evaluate 8 COLT that could be used in the process of forming the professional competencies of future bachelors of statistics.

20 experts of different profiles were invited to the expert evaluation procedure, among them officials of the State Statistical Service of Ukraine and the State Treasury in Zhytomyr, employees of banking institutions, employees of commercial financial institutions.

A point scoring system was used in the study [19]. According to the aforementioned evaluation system, for the number of N COLT, the maximum possible estimate of N is given to the most significant in the use of COLT and 1 to the least significant. The results of the assessment are presented in the form of a table, where the columns indicate the hotline number and the fields the expert number. The COLT name card is presented in alphabetical order (A to Z), to prevent psychological clues that could affect the outcome of the assessment.

To determine whether there is an objective agreement between experts, calculated concordance coefficient Kendall’s W [20] by the formulas:

$$W = \frac{S(d^2)}{S_{max}(d^2)} = \frac{12 \cdot S(d^2)}{m^2(n^3 - n)} \quad (1)$$

$$S(d^2) = \sum_{j=1}^{n} d_j^2 \quad (2)$$

$$d_j = S_j - 0{,}5 \cdot m \cdot (n+1) \quad (3)$$

$$S_j = \sum_{i=1}^{n} R_{i,j} \quad (4)$$

Where:

S_j – is the total rank of the *j*-th indicator (it should be noted that this is the main parameter for evaluating the significance of the indicator);

j = 1, 2, 3, ..., *n; n* is the number of indicators;

m – number of experts;

$R_{i,j}$ – is the rank of the *j*-th indicator, determined by the *i*-th expert.

Applying formulas (1) to (4) for the sake of calculations, obtain a certain value W based on the experimental data. If the results of the calculations differ significantly from zero, this means that there is an objective agreement between the experts (if W=0, it is considered that there is no correlation between the ranking of experts, at W=1, the rankings are completely identical) and the total ranks are quite objective.

The results of the peer review are presented in Table 1.

Table 1. Ranking Cloud-Oriented Learning Technologies for the formation of the professional competencies of future bachelor of statistics.

COLT / Expert number	CoCalc	Excel Online	GeoGebra	Google Sheets	MapleCloud	Scilab	WebMathematica	Wolfram|Alpha
1	6	4	2	1	3	5	7	8
2	6	5	1	2	3	4	8	7
3	8	1	2	3	4	5	7	6
4	5	3	2	1	4	8	7	6
5	5	2	1	4	3	6	7	8
6	6	1	5	2	3	4	8	7
7	8	2	3	1	5	4	7	6
8	5	3	1	2	4	6	7	8
9	6	1	4	3	2	5	8	7
10	7	1	2	3	4	8	5	6
11	7	3	2	4	1	6	5	8
12	5	2	3	6	1	4	8	7
13	8	1	2	3	4	5	6	7
14	6	4	1	3	2	5	8	7
15	7	4	1	3	2	5	6	8
16	5	3	2	4	1	6	8	7
17	8	2	1	3	5	4	7	6
18	7	1	2	3	4	8	5	6
19	4	3	2	1	8	7	5	6
20	7	4	1	2	3	6	5	8
S	**126**	50	40	54	66	**111**	**134**	**139**
d	36	-40	-50	-36	-24	21	44	49

The result was selected COLT 4: CoCalc, Scilab, WebMathematica, Wolfram|Alpha.

After calculating (by formulas 1–4) based on the experimental data presented (see Table 1), obtained a coefficient of concordance W = 0.71. Since the value obtained is non-zero, there is an objective agreement between experts.

In the second phase of the study, another group of specialists was recruited to evaluate the most significant COLT according to certain criteria. It is worth noting that the second stage involved 15 specialists of different profiles, namely: teachers, heads of departments and deans of faculties of higher education institutions of Ukraine, having experience and related to the professional training of future bachelors of statistics, employers (Department of Statistics in Zhytomyr region, Department of the State Treasury Service of Ukraine in Zhytomyr, Main Department of State Tax Service in Zhytomyr region, heads of state and commercial banks, managers financial companies), which worked directly with the selected COLT and could objectively evaluate them according to the degree of manifestation of each criterion.

The manifestation of each of the presented criteria was evaluated for each of this COLT. To this end, experts have been asked to evaluate its performance using the scale shown in Table 2.

Table 2. Scale bar for evaluation of the relevant criteria

Scores	Evaluation of the indicator
0	the indicator is missing
1	the indicator is partially available (not available more than available)
2	the indicator is more available than not available
3	the indicator is completely available

The indicator will be considered positive if the arithmetic mean of these points is at least 1.5. If more than half (50%) of the indicators of the relevant criterion are negative, then the criterion is defined as insufficiently developed. In the case of:

- when 50-55% of the indicators of the criterion are positive, the criterion is characterized as critically manifested;
- if 56-75% of the indicators of the criterion are positive, then the criterion is characterized as sufficiently manifested;
- if 76–100% of the criterion indicators are positive, then the criterion is characterized as highly manifested [19].

An analysis of existing cloud-oriented learning technologies to shape the professional competencies of future bachelors of statistics [21] has made it possible to identify the criteria and relevant indicators of these cloud-oriented learning technologies:

- information-didactic: information support; coverage of various sections of mathematics and statistics; graphical presentation of results; teamwork on the project; ability to apply programming knowledge;
- functional: user-friendly interface; free of charge; accessibility; multilingualism;
- technological: cross-platform; integration with other cloud services; adaptability.

The results of the peer review of each of the selected criteria and relevant indicators will be discussed in more detail.

The **information-didactic criterion** characterizes the information and didactic component of cloud-oriented learning technology and is based on the laws of assimilation of knowledge, skills, and competences, namely:

1.1. the indicator “information support” characterizes the presence of a description of the use of the tool, examples, or the presence of a section of assistance;

1.2. the indicator “coverage of various sections of mathematics and statistics” characterizes the possibility of using COLT in the process of studying certain sections of mathematics and statistics;

1.3. the indicator “graphical presentation of results” characterizes the ability to interpret the results in the form of graphs, histograms or a three-dimensional model;

1.4. the indicator “teamwork on the project” characterizes the ability to work with multiple users at the same time;

1.5. the indicator “ability to apply programming knowledge” characterizes the ability to take individual actions to perform calculations using different programming languages.

Basic data on indicators of information-didactic criteria for each of the selected COLT contains table 3.

Table 3. The information-didactic criterion for selection of cloud-oriented learning technologies and the value of its indicators.

The indicators / **COLT**	information support	coverage of various sections of mathematics and statistics	graphical presentation of results	teamwork on the project;	ability to apply programming knowledge	The manifestation of the criterion	The level of manifestation
CoCalc	1.93	2.67	2.07	1.80	2.00	**100%**	highly
Scilab	2.13	2.20	0.80	0.80	2.33	**60%**	suffi-ciently
WebMathematica	1.47	2.00	1.33	1.53	2.13	**80%**	highly
Wolfram|Alpha	2.33	2.27	2.33	1.53	2.33	**100%**	highly

The functional criterion characterizes the functional component of cloud-oriented learning technologies and assumes the following indicators:

2.1 the indicator “user-friendly interface” describes the convenience and comprehensibility of the interface and the computational component of the hot-water system;

2.2 the indicator “accessibility” characterizes the provision of cloud-oriented learning technology to different categories of users;

2.3 the indicator “free of charge” characterizes the possibility of free or full use of cloud-oriented learning technologies;

2.4 The indicator “multilingualism” characterizes the support of multiple languages (localization) of the interface.

The basic data on the indicators of the functional criterion for each of the selected COLT contains table 4.

The **technological** criterion is characterized as follows:

3.1 “cross-platform” indicates the possibility of using cloud-oriented learning technologies in different operating systems;

3.2 the indicator “integration with other cloud services” implies the possibility of supporting the work with calculations in different cloud services, and the possibility of further integration with other services;

3.3 “Adaptability” indicates the possibility of full use of cloud-oriented learning technologies on different devices (desktop PC, laptop, netbook, tablet, smartphone, etc.).

Table 4. The functional criterion for the selection of cloud-oriented learning technologies and the value of its indicators.

The indicators / **COLT**	user-friendly interface	free of charge	accessibility	multilingualism	The manifestation of the criterion	The level of manifestation
CoCalc	1.80	2.00	2.20	1.80	**100%**	highly
Scilab	2.00	1.87	2.13	1.53	**100%**	highly
WebMathematica	1.73	1.87	1.73	1.93	**100%**	highly
Wolfram|Alpha	2.13	2.53	2.20	1.60	**100%**	highly

The basic data on the indicators of the technological criterion for each of the selected COLN contains table 5.

Table 5. The technological criterion for the selection of cloud-oriented learning technologies and the value of its indicators.

The indicators / **COLT**	cross-platform	integration with other cloud services	adaptability	The manifestation of the criterion	The level of manifestation
CoCalc	1.53	1.53	1.93	**100%**	insufficiently
Scilab	1.53	1.53	1.53	**100%**	highly
WebMathematica	1.73	1.73	1.93	**100%**	sufficiently
Wolfram|Alpha	2.60	2.33	2.93	**100%**	sufficiently

Let’s summarize the results of the study in table 6.

Table 6. Generalized results of the selection of cloud-oriented learning technologies by the manifestation of all criteria.

Criterion / **COLT**	Information-didactic	Functional	Technological
CoCalc	**100%**	**100%**	**100%**
Scilab	**60%**	**100%**	**100%**
WebMathematica	**80%**	**100%**	**100%**
Wolfram|Alpha	**100%**	**100%**	**100%**

4 Conclusions

Therefore, according to the research, the most appropriate, convenient and effective cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics by the manifestation of all criteria are cloud-oriented learning

technologies CoCalc and Wolfram|Alpha. In the future, according to the results of the expert evaluation, a model of using cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics will be developed, and a methodology for using cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics will be described.

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