Selection Cloud-oriented Learning Technologies for the Formation of Professional Competencies of Bachelors Majoring in Statistics and General Methodology of Their Use

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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. The general structure of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics is described.

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 Traditional learning is out of date and needs updating, replenished with new technologies, forms, means, and is confirmed in the text of the National Doctrine of Educational Development that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" (President of Ukraine, 2002).

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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 (Kremen, 2016).

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).

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 (Bykov et al., 2014; Golovnia, 2015; Demyanenko et al., 2013; Kolos, 2013)

In particular, Bykov et al. (Bykov et al., 2014) considered open web-oriented systems for monitoring the implementation of scientific and pedagogical research results. Golovnia (Golovnia, 2015) in her works investigated the virtualization software in the training of UNIX-like operating systems and identified the criteria and indicators of their selection. Demyanenko et al. (Demyanenko et al., 2013) give methodological recommendations on the selection and use of electronic tools and resources for educational purposes. Kolos (Kolos, 2013) has developed criteria for selecting components of a computer-oriented educational environment for a postgraduate teacher education institution. Spirin (Spirin, 2011) offers criteria for external evaluation of the quality of information and communication training technologies.

The use of cloud technologies in education is shown in (Shyshkina and Marienko, 2020; Valko et al., 2020; Lovianova et al., 2019; Lytvynova, 2018; Merzlykin et al., 2017; Symonenko et al., 2020; Popel et al., 2017; Velychko et al., 2020; Vlasenko et al., 2020; Volikova et al., 2019).

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 Korotun (Korotun, 2018). The question of designing a cloud-oriented educational environment of a comprehensive educational institution was also investigated by Lytvynova (Lytvynova, 2016). Several teams of authors have considered cloud technologies in learning at different intervals (Shyshkina and Popel, 2013; Valko et al., 2020; Lytvynova, 2018; Glazunova et al., 2017; Seidametova et al., 2012; Markova et al., 2015; Striuk and Rassovytska, 2015). 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 and to develop a general methodology for the use of selected cloud-based learning technologies for the specified type of activity.

2 METHODS

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 (Zastelo, 2015; Gavryliuk et al., 2020). 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.

In the second phase of the study, another group of specialists was recruited to evaluate the most significant COLT according to certain criteria.

3 RESULTS

3.1 Selection of Cloud-based Learning Technologies for the Formation of Professional Competencies of Future Bachelors of Statistics

Research on the implementation of cloud-oriented learning technologies to shape the professional com-

petencies 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" (Busel, 2005).

In (Honcharenko, 2000) the criterion is called "the criterion for evaluating something, a means of verifying the truth or falsehood of a statement".

Bagrii (Bagrii, 2012) argues that the criterion is "a standard against which to evaluate, compare a real pedagogical phenomenon, process, or quality by reference".

Torchevsky (Torchevsky, 2012) 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".

In Dychkivska (Dychkivska, 2004) term "criterion" is defined 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".

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.

We apply the method of expert evaluation (Zastelo, 2015; Gavryliuk et al., 2020). 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 (Spirin and Vakaliuk, 2017). 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 Kendall's Concordance Coefficient W by the appropriate formula specified in (Zastelo, 2015; Gavryliuk et al., 2020).

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

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

After calculating based on the experimental data presented (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 (Main 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.

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,

Table 1: Ranking cloud-oriented learning technologies for the formation of the professional competencies of future bachelor of statistics.

Expert number	COLT							
	CoCalc	**Excel Online**	**GeoGebra**	**Google Sheets**	**Maple Cloud**	**Scilab**	**Web Mathematica**	**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

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

then the criterion is characterized as highly manifested (Spirin and Vakaliuk, 2017).

An analysis of existing cloud-oriented learning technologies to shape the professional competencies of future bachelors of statistics 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:

- 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;
- 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;
- the indicator “graphical presentation of results”

characterizes the ability to interpret the results in the form of graphs, histograms, or a three-dimensional model;

- the indicator "teamwork on the project" characterizes the ability to work with multiple users at the same time;
- 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.

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

- the indicator "user-friendly interface" describes the convenience and comprehensibility of the interface and the computational component of the software system;
- the indicator "accessibility" characterizes the provision of cloud-oriented learning technology to different categories of users;
- the indicator "free of charge" characterizes the possibility of free or full use of cloud-oriented learning technologies;
- 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 in table 4.

The technological criterion is characterized as follows:

- "cross-platform" indicates the possibility of using cloud-oriented learning technologies in different operating systems;
- 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;
- "adaptability" indicates the possibility of full use of cloud-oriented learning technologies on different devices (desktop PC, laptop, netbook, tablet, smartphone, etc.).

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

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

3.2 The General Structure of the Methodology of using Cloud-based Learning Technologies for the Formation of Professional Competencies of Future Bachelors of Statistics

The formation of professional competencies is a long process that requires, in addition to appropriate teacher training, the use of appropriate methods of its implementation.

The methodology of using cloud-based learning technologies for the formation of professional competencies of future bachelors of statistics includes the purpose of the application, the content of an application, interrelated forms of training, methods, and tools for achieving a predictable result.

The expected result of the methodology is the formed professional competencies of future bachelors of statistics in the specialty 112 "Statistics".

The purpose of using cloud-based learning technologies is to form in future bachelors' statistics of professional competencies.

The content of the methodology involves improving the learning process of disciplines of general training of the variable part of the free choice of students using cloud-based learning technologies (on the example of the content of the variable discipline of "Computer Statistics").

Note the features of teaching the discipline "Computer Statistics" for the training of future bachelors of statistics using cloud-based learning technologies.

To improve and enhance the discipline "Computer Statistics" carried out:

- selection of cloud-based learning technologies that are appropriate and reasonable to use in the learning process of future bachelors of statistics, to form their professional competencies;
- improving the content of the variable discipline "Computer Statistics" for the use of cloud-based learning technologies during the acquaintance and mastery of relevant topics of the course;
- development of methodical recommendations on the use of cloud-based learning technologies in the educational process of the discipline "Computer Statistics".

The purpose of the discipline is based on the mastery of practical skills of future professional activity in conditions that are as close as possible to the real ones; to form professional competencies in applicants related to a thorough knowledge of the chosen field

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

COLT	The indicators						
	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%	sufficiently
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

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

COLT	The indicators					
	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

of statistics, the ability to perform a qualitative analysis of data or calculations, calculations of relevant processes, the ability to work with statistical information, the use of appropriate software and cloud services, able to work both independently and in a team.

The study of the discipline "Computer Statistics" assumes that applicants for the specialty 112 "Statistics" *must know* the basic concepts of mathematical statistics; stages of statistical research; specialized programming languages, in particular, the statistical programming language R; software for working with statistical data; specialized cloud services for organizing work with statistical information; features of the organization of joint work using cloud services; *be able* to perform statistical calculations; perform statistical calculations using specialized software; perform statistical calculations using appropriate cloud services; transmit and receive statistics; analyze the obtained data; build and edit schedules; visualize the received data with the help of specialized cloud services; organize joint activities with other specialists of the relevant activity or clients for whom the statistical survey is carried out.

Consider the modules that form the content of the advanced program of the discipline "Computer Statistics":

Module 1. Working with data. Basics of work in R.

Content module 1. Basic concepts, data types, and elementary functions. Arithmetic and logical operations. Basic mathematical functions. Vectors. Matrices. Arrays and data frames.

Content module 2. Export and import of data in R. Export of data, import of data in internal format. Export and import data tables.

Content module 3. Programming in R. Creating your functions. The technique of vectorization of the function. Conditional use (if) and multi-conditional (switch) operations. While and repeat loops. Cycle for.

Module 2. Basic concepts of statistical distribution.

Content module 4. Basic probability distributions. General concepts of distribution. The most commonly used distributions.

Content module 5. Graphic representation of statistical distributions. Points on the plane. Charts. Construction of histograms. Elements of three-dimensional graphics.

Module 3. Statistical evaluation and statistical testing

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

COLT	The indicators				
	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%	highly
Scilab	1.53	1.53	1.53	100%	highly
WebMathematica	1.73	1.73	1.93	100%	highly
Wolfram Alpha	2.60	2.33	2.93	100%	highly

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

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

of hypotheses.

Content module 6. Evaluation of unknown parameters. The method of moments. Quantile method. The method of the highest probability. Confidence intervals.

Content module 7. Test of statistical hypotheses. General concepts of the theory of hypothesis testing. Algorithm for testing statistical hypotheses. Pearson's criterion. Kolmogorov's criterion.

The proposed technique involves the use of the following teaching methods of selected cloud-based learning technologies (CoCalc and Wolfram Alpha, as described above and in (Gavryliuk et al., 2020)):

- *Explanatory and illustrative*. Statistics as a science is quite complex and contains many sections that contain a significant amount of theoretical material, theorems and proofs, formulas, and graphical constructions of relevant processes. The explanatory-illustrative method as the most appropriate to use because students receive accurate theoretical material from the teacher, or independently from the textbook or textbook with subsequent discussion in class or online, and receive a visual presentation of the material using selected cloud-based learning technologies, demonstration of practical application cloud-based learning technologies CoCalc and Wolfram Alpha (figure 1). Explaining the theoretical aspects of statistics is a basic factor influencing students' further understanding of the following related topics in the course, the use of cloud-based learning technologies to effectively perform professional tasks and the formation of professional competencies of future bachelors of statistics.
- *Reproductive*. Given the accuracy and complexity of the theoretical material, the course of the discipline "Computer Statistics" provides for laboratory and practical work, which is planned to practice tasks of varying complexity according to the specified algorithm according to the relevant educational topic, as well as a demonstration of their cloud-based learning technologies. CoCalc and Wolfram Alpha followed by a repetition of the action scenario by the students. It is planned to present ready-made solved exercises and perform exercises in a similar way (two or three exercises or tasks). Also, it can be pre-prepared by the teacher sets of statistics provided to students as a separate file in the cloud storage or ready-presented statistical sets presented on the MEI page (Mathematics Education Innovation, http://mei.org.uk/data-sets), or on Google Public Data, Google Dataset Search services.
- The method of *problem statement* can be effectively used during practical or independent work, during which students do not receive samples of problem-solving or ready-made algorithms for working with cloud-based learning technologies. The teacher describes the problems or asks the formed problem question (one or more), describes the ways to solve the problem, acts as a mentor who guides the work of students. Working in such circumstances promotes the development of students' critical thinking, solving atypical situations, and forms professional competencies, in particular, to develop research and analyze the data obtained; ability to present the results to the

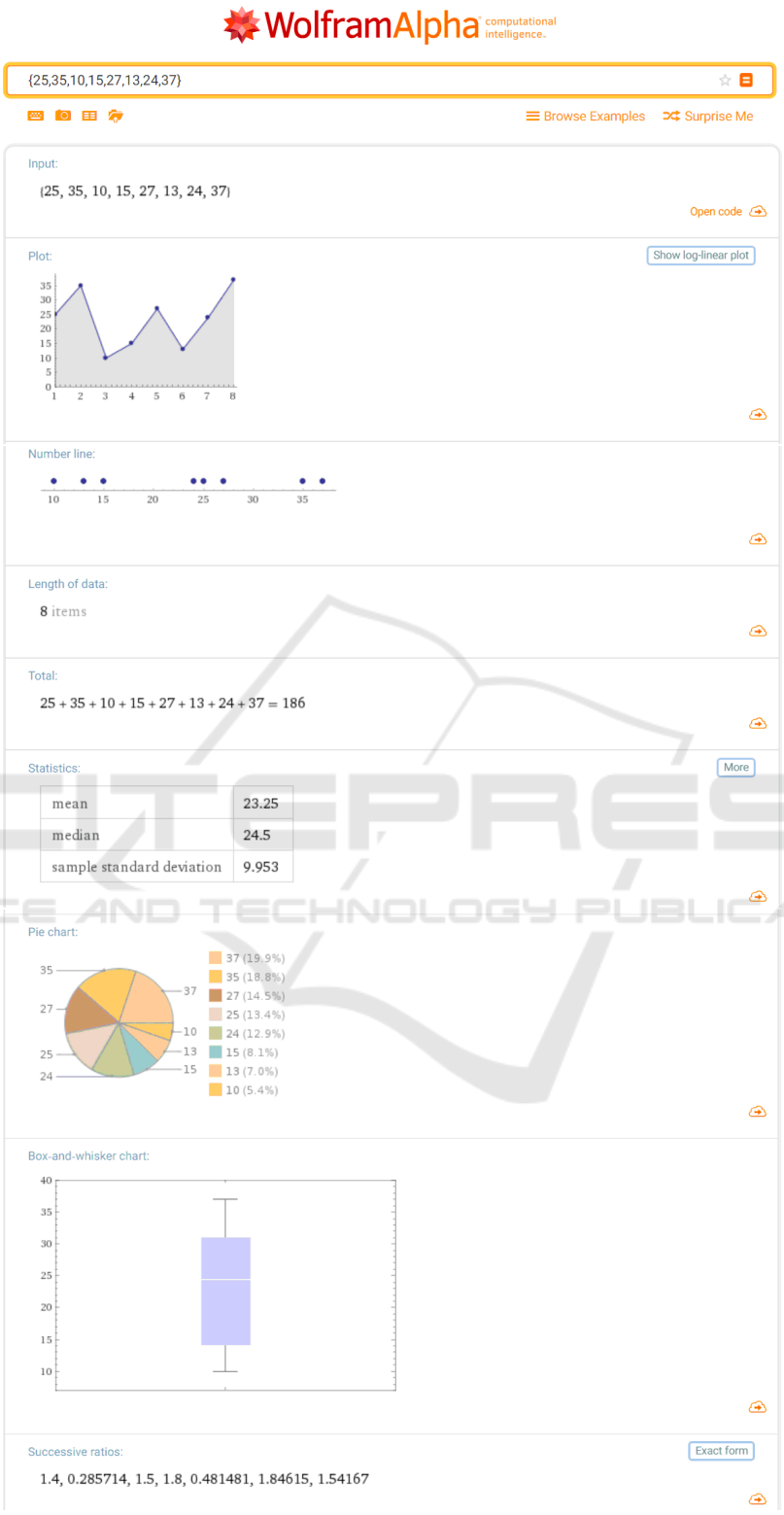

Figure 1: The result of sampling calculations in the Wolfram Alpha service.

target audience; ability to work in a team.

- *Partial search*. The study material is presented by the teacher in part (a certain part of the topic), and the rest of the students work independently. However, the teacher directs the work of applicants with questions or pre-selected tasks to prevent errors in their activities or found the wrong solution.
- *Research*. The method is quite difficult to use because it requires additional training from the teacher and is quite time-consuming. Provides independence of students in the study of a particular topic or theoretical aspect, its practical implementation in cloud-based learning technologies CoCalc, Wolfram Alpha, or the study of additional topics related to the topic of the course, but not considered due to time constraints on learning discipline. Researching the problem develops the ability to conduct research, the ability to use hardware and specialized cloud services, obtain additional data and interpret them, the ability to work independently, all together are components of professional competencies formed at the appropriate level of a successful future statistician.

The means of forming the professional competencies of future bachelors of statistics, which are specified in the presented methodology using cloud-based learning technologies, include CoCalc and Wolfram Alpha, textbooks or teaching materials, as well as computers (laptops, tablets, smartphones) with an active connection to the Internet.

The result of the proposed methodology is the formed professional competencies of future bachelors of statistics at a high level, as well as the successful application of skills to use CoCalc and Wolfram Alpha to perform practical work in the professional field.

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. The general structure of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics is described. In the future, it is planned to describe in more detail the individual components of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics, in particular the forms of use and forms of organization of the educational process.

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