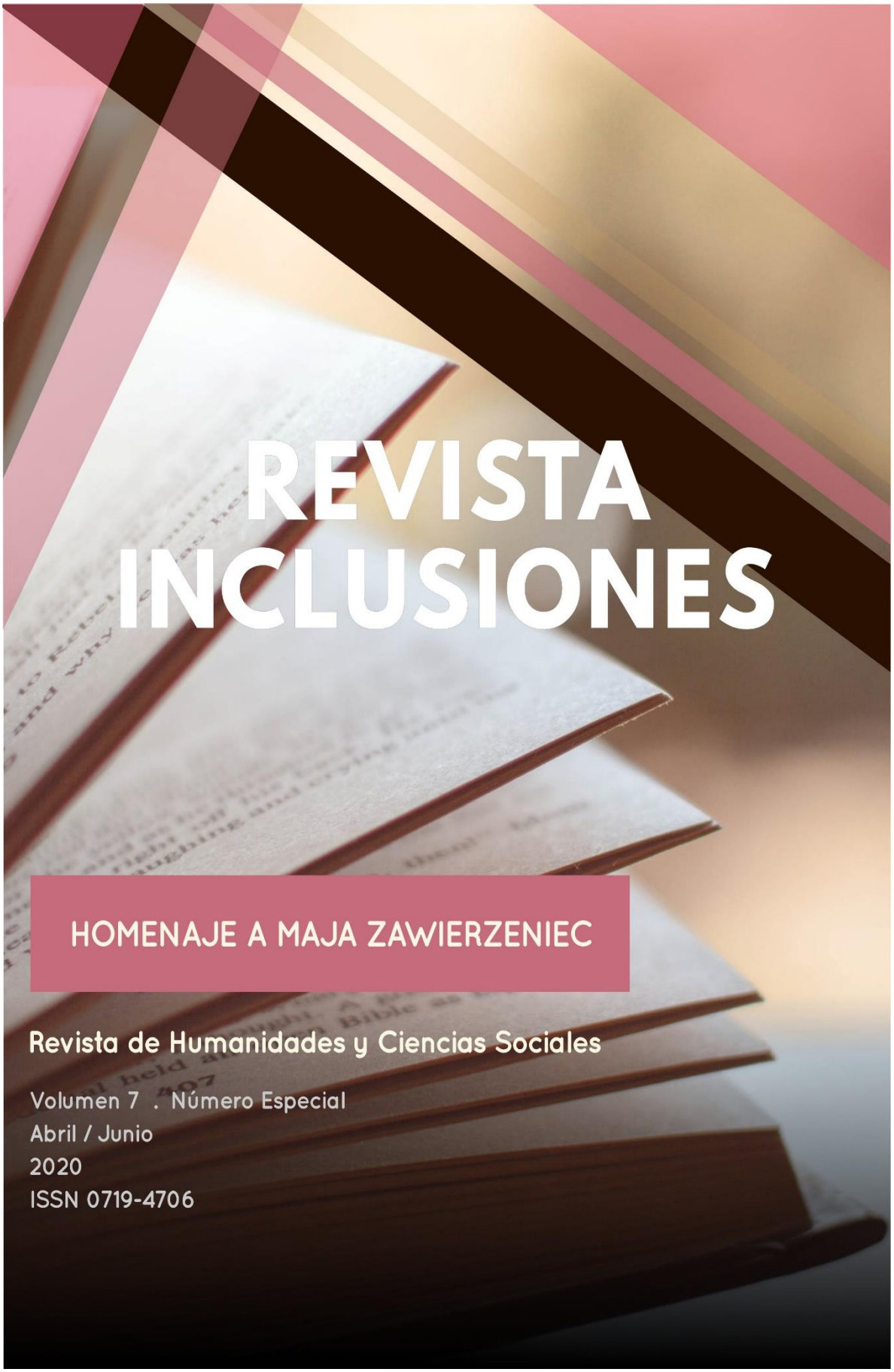

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CRITERION ANALYSIS OF CLOUD-BASED TOOLS IN DATABASE BASICS TRAINING

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Abstract

The formation and development of an educational environment on the basis of cloud computing technology is an urgent area in the modern renewal of higher education. It is associated with the spread of more convenient systems for organizing access to electronic resources and services, the possibilities of teamwork with software applications. The article presents an analysis of studies on various aspects of the use of cloud-based tools in the educational process. Based on the results of the expert survey, the ranking and selection of the most acceptable cloud-based training tools for teaching the database basics were carried out. The study defines the criteria and indicators for the selection of cloud-based tools, on the basis of which a criteria-based analysis of cloud-based tools was carried out when teaching the basics of databases. It is concluded that the introduction of cloud-based tools into the educational process of teaching the basics of databases is necessary on the basis of compliance with the functional and didactic and organizational criteria.

Keywords

Cloud technologies – Foggy technologies – Cloud-based tools – Databases

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Introduction

The process of training future specialists at higher education institutions provides for the mandatory study of databases in a separate discipline[1]. In database training, the teacher focuses on the peculiarities of database technologies so that students understand the main trends of modern database development, advantages and disadvantages of using databases, specifics of working in database management systems (DBMSs), etc.[2]

The acquired knowledge, skills and abilities to work with databases are necessary for future specialists in their professional activities[3]. To increase the effectiveness of the educational process in teaching databases and improving the professional training of future specialists, university teachers need to use the latest teaching aids, including cloud-based ones[4].

Cloud technologies are Internet technologies that provide a way to process data through online services and provide for the implementation of basic functions through data centers[5]. In other words, these are technologies that constantly store the user's information content on Internet servers; the information is only temporarily cached (stored) by the user on stationary computer systems[6].

Today, "foggy" technologies stand out within the framework of cloud technologies – these are cloud technologies that are characterized by the distribution of computing among devices belonging to the Internet of Things (in particular, smartphones that almost everyone uses today have processors that are not actively used). When using cloud technologies, secondary data are created from shared resources and always transmitted to the "cloud" (to a remote server)[7]. This is characteristic of the well-known cloud services YouTube (a video hosting company that provides users with services for storing, searching and displaying video materials), Office365 (a cloud Internet service and Microsoft software distributed according to the "software + services" scheme), etc.

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[1] I. G. Doronkina; E. E. Krasnovskiy; E. V. Zakharova; P. V. Ulianishchev y L. V. Ulyanishcheva, “Academic Cloud Services: Innovative Solutions and International Practice”, Journal of Advanced Research in Dynamical and Control Systems, Vol: 11 num Especial (2019): 65-72 y T. N. Yudina; M. G. Kotovskaya; M. V. Zolotukhina y D. K. Tananova, "I Identify Myself as Russian Although I Have Never Been to Russia": Ways of Transferring Identity and Language to Children among the Russian-Speaking Population of the USA”, Rupkatha Journal on Interdisciplinary Studies in Humanities, Vol: 11 num 2 (2019).

[2] A. M. Popova; V. V. Mironov y N. I. Romanchuk, “Visual Programming Environment Scratch in The Study of the School Subject "Fundamentals of Life Safety", International Journal of Advanced Trends in Computer Science and Engineering, Vol: 8 num 6 (2019): 3488-3491 y M. S. Logachev y G. S. Zhukova, “Problems of Professional Education in Russia: Quality Monitoring of Educational Programs”, Revista Inclusiones, Vol: 7 num Especial (2020): 263-274.

[3] E. I. Danilina; I. I. Malikova y D. V. Gorelov, “State and Municipal Programs to Support Staff of Insolvent Public Transport Companies”, Revista Inclusiones, Vol: 7 num 1 (2020): 176-189.

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[5] J. Reese, Oblachnye vyshisleniya (St. Petersburg: BHV-Petersburg, 2011).

[6] A. Weiss, “Computing in the Clouds”, Networker, Vol: 11 num 4 (2007): 16-25.

[7] I. Stojmenovic y S. Wen, The Fog Computing Paradigm: Scenarios and Security Issues. In Proceedings of the Federated Conference on Computer Science and Information Systems. 2014. 1-8.

The analysis of the studies[8] shows that a resource is a cloud service if it offers online data processing and performs certain actions: its use involves both viewing the content created by others and online communication, as well as the development and addition of one's own learning materials.

The use of such teaching technologies in the educational process is now an urgent issue in the theory and methodology of using information and communication technologies in education.

In general, an analysis of scientific research showed that a number of works highlighted the theoretical and practical foundations of the use of cloud computing and cloud services in the educational process[9].

The basic concepts of database theory, the database normalization process, database design methodology, database architecture, modern DBMSs, the SQL query language and the issues of their study at universities are covered in the studies[10].

However, researchers are not paying enough attention to the issue of introducing and using cloud computing in teaching the basics of databases.

The aim of the article is to carry out the selection of cloud-based learning tools for databases of students of higher education institutions by expert assessment.

The hypothesis of the study is as follows: the introduction of cloud-based tools into the educational process of teaching the basics of databases is necessary on the basis of compliance with the functional and didactic and organizational criteria.

According to the results of the study, it can be concluded that the goal set in the study was achieved.

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[8] R. Buyya; C. S. Yeo; S. Venugopal; J. Broberg y I. Brandic, “Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility”, Future Generation Computer Systems, num 25 (2009): 599-616; L. M. Vaquero; L. Rodero-Merino; J. Caceres y M. Lindner, “A Break in the Clouds: Towards a Cloud Definition”, SIGCOMM Computer Communications Review, num 39 (2009): 50-55 y C. Gong; J. Liu; Q. Zhang; H. Chen y Z. Gong, The Characteristics of Cloud Computing. In (Parallel Processing Workshops (ICPPW), 2010 39th International Conference, 2010).

[9] A. N. Dukkardt; D. S. Saenko y E. A. Sleptsova, “Oblachnye tekhnologii v obrazovanii”, Otkrytoe obrazovanie, num 3 (2014): 68-74; K. Yadav, “Role of Cloud Computing in Education”, International Journal of Innovative Research in Computer and Communication Engineering, Vol: 2 num 2 (2014): 3108-3112; C. Bulla; B. Hunshal y S. Mehta, “Adoption of Cloud Computing in Education System: A Survey”, IJESC, Vol: 6 num 6 (2016): 63-75 y K. Kurelović; S. Rako y J. Tomljanović, Cloud Computing in Education and Student’s Needs. In (2013 36th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2013).

[10] J. Van den Bussche, “Constraint Databases: A Tutorial Introduction”, SIGMOD Record, Vol: 29 num 3 (2000): 44-51; J. S. Vitter, “External Memory Algorithms and Data Structures: Dealing with Massive Data”, ACM Computing Surveys, num 33 (2001): 209-271 y V. V. Osipova; I. L. Chudinov y A. S. Seidova, “Formalized Approach in Relational Database Design Key”, Engineering Materials, Vol: 68 num 5 (2016): 930-933.

Methods

To carry out the selection of cloud-based tools (CBTs) for training students of higher education institutions in the basics of databases, the method of expert evaluation was applied.

According to this method, CBTs for teaching the basics of databases are numbered in ascending or descending order according to a certain criterion for their further ranking. The survey of experts was carried out in two stages.

The first stage of the survey of experts. Specialists were asked to evaluate 7 well-known CBTs that could be used to teach the database basics to students of higher education institutions. For the purpose of expert evaluation, specialists of this profile were involved – teachers who had experience and were directly related to teaching the database basics (12 people in total). The experts were the indicated categories of the faculty of universities.

As part of the study, they used a point-based grading system, according to which for the seven CBTs selected for assessment:

- the maximum score of 7 points would be given to the CBT that was most significant in the use;

- the minimum score of 1 point would be given to the CBT that was the least significant in the use.

To establish the existence of objective coordination among experts, the Kendell's concordance coefficient was determined by the formula:

$$W = S(d^2) / S_{max}(d^2) = 12S(d^2) / m^2(n^3 - n),$$

where

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

$$d_j = S_j - 0.5m(n + 1);$$

$$S_j = \sum_{i=1}^{m} R_{i,j}$$

S_j was the total rank of the j-th indicator (the main parameter for assessing the significance of the indicator); j = 1, 2, 3 ... n; n was the number of indicators; m was the number of experts; $R_{i,j}$ was the rank of the j-th indicator, determined by the i-th expert.

After performing the necessary calculations using experimental data, one can obtain a certain value of the Kendell's concordance coefficient W. If the calculation results significantly differ from zero, it can be determined that there is an objective agreement

among the experts (W = 0 – there is no connection among the ranking of experts, W = 1 – the ranking completely coincides), total ranks are fairly objective.

In the second stage of the study, a group of specialists was involved to determine the most significant CBTs for teaching the students of higher education institutions according to certain criteria.

The manifestation of each of the presented criteria was evaluated for each of the indicated CBTs for teaching the basics of databases to students of higher education institutions according to the following scale: 0 points – no indicator; 1 point – the indicator was more absent than present; 2 points – the indicator was more present than not present; 3 points – the indicator was fully present.

An indicator is considered positive if the arithmetic mean value of all indicators of this criterion is not less than 1.5.

Moreover, the criterion is considered: insufficiently developed if more than 50% of its indicators are negative; critically manifested if 50-55% of its indicators are positive; sufficiently manifested if 56-75% of its indicators are positive; highly manifested if 76-100% of its indicators are positive.

Results

To compile a list of the proposed CBTs, an online survey of teachers directly related to the teaching of databases was carried out in order to establish which CBTs for teaching the basics of databases were used at various universities. As a result, a list of the most used CBTs was formed (Table 1).

No.	CBT name
1.	Amazon RDS
2.	Google Cloud SQL
3.	Heroku PostgreSQL
4.	Microsoft SQL Azure
5.	Oracle Database Cloud Service
6.	Rackspace Cloud Databases
7.	SQLite Viewer

Table 1
Most used CBTs

In the first stage, the experts were asked to take an online survey in order to rank the CBTs for learning the database basics (see Table 1), the results of which are presented in Table 2.

Expert No.	CBT						
	Amazon RDS	Google Cloud SQL	Heroku PostgreSQL	Microsoft SQL Azure	Oracle Database Cloud Service	Rackspace Cloud Databases	SQLite Viewer
1	4	5	3	6	2	1	7
2	5	4	2	7	1	3	6

3	3	6	4	5	2	1	7
4	1	5	4	7	2	3	6
5	4	5	3	6	1	2	7
6	3	6	4	7	1	2	5
7	4	6	1	5	2	3	7
8	4	5	2	7	3	1	6
9	5	6	1	4	2	3	7
10	2	5	3	7	4	1	6
11	4	6	1	5	3	2	7
12	4	5	2	6	3	1	7
S	43	64	30	72	26	23	78
d	-5	16	-18	24	-22	-25	30

Table 2
Ranking of CBTs for Database Basics Training

Having performed the calculations according to formulas (1) – (4) according to the data in Table 2, one can obtain: $S(d^2) = (-5)^2 + 16^2 + (-18)^2 + 24^2 + (-22)^2 + (-25)^2 + 30^2 = 3190$

$$W = 12 \cdot 3190 / 12^2 \cdot (7^3 - 7) = 0.79$$

Therefore, the Kendell's concordance coefficient W = 0.79 differed from zero, thus there was an objective agreement among the experts.

As a result, three CBTs were selected, namely: Google Cloud SQL, Microsoft SQL Azure, SQLite Viewer.

For the second stage of the survey of experts, the following criteria and indicators for the selection of environmental education for teaching the basics of the database were defined:

- functional and didactic: the ability to create, edit and delete tables in the database; definition of primary and foreign keys in the table; creating relationships between database tables; data modification in database tables; the ability to analyze results and errors in requests;

- organizational: availability (free version; the validity period of the free version); confirmation of the financial viability of the user; the convenience of the interface.

The functional and didactic criterion characterized the functional and didactic component of the CBTs, its basis was the assimilation of knowledge of the general structure of the SQL query language and the practical skills of using this language to work with database objects. The indicators of this criterion were as follows:

- the *ability to create, edit and delete tables in the database* determined whether the CBT had the ability to use SQL commands to create, edit and delete tables in the database;

- *definition of primary and foreign keys in the table* – availability in the CBT of the possibility of creating primary and foreign keys in the database tables;

- *creating relationships between database tables* – the ability in the CBT to configure the relationships between database tables;

- *modification of data in database tables* – availability in the CBT of the ability to add, edit and delete data in database tables;

- *the ability to analyze results and errors in requests* – the presence in the CBT of the ability to analyze the results of query execution and errors when writing requests.

The results of the intermediate data of the expert survey by the functional and didactic criterion are presented in Tables 3-5.

Expert number	The number of points by indicator				
	1	**2**	**3**	**4**	**5**
1	3	3	3	2	2
2	3	3	3	3	2
3	3	3	3	3	3
4	2	3	2	2	2
5	3	3	3	3	2
6	3	2	3	3	3
7	3	3	3	3	2
8	3	2	3	2	2
9	3	3	3	2	3
10	2	2	3	3	3
11	2	3	3	3	3
12	3	3	3	3	2
Average	2.75	2.75	2.92	2.67	2.42

Table 3

Google Cloud SQL CBT assessment results by the functional and didactic criterion

Expert number	The number of points by indicator				
	1	**2**	**3**	**4**	**5**
1	3	3	2	3	3
2	3	3	3	3	3
3	3	3	3	3	3
4	2	3	2	3	3
5	3	3	3	2	3
6	3	3	3	3	3
7	2	3	2	3	3
8	2	3	3	2	3
9	3	2	3	3	2
10	3	3	3	2	3
11	3	2	2	3	3
12	3	3	3	3	3
Average	2.75	2.83	2.67	2.75	2.92

Table 4

Microsoft SQL Azure CBT assessment results by the functional and didactic criterion

Expert number	The number of points by indicator				
	1	**2**	**3**	**4**	**5**
1	3	3	3	3	3
2	3	3	3	3	3
3	3	2	2	3	3
4	2	3	3	2	3
5	3	2	3	3	2
6	3	3	3	3	3
7	3	3	3	3	3
8	3	3	3	2	3
9	3	3	3	3	2
10	3	3	3	3	3
11	3	3	2	2	3
12	3	2	2	3	3
Average	2.92	2.75	2.75	2.75	2.83

Table 5

SQLite Viewer CBT assessment results by the functional and didactic criterion

Let us consider the results on the indicators of the functional and didactic criterion for each CBT for teaching the database basics (Table 6).

CBT for teaching the database basics	Indicators					Manifestation of the criterion
	1	**2**	**3**	**4**	**5**	
Google Cloud SQL	2.75	2.75	2.92	2.67	2.42	100%
Microsoft SQL Azure	2.75	2.83	2.67	2.75	2.92	100%
SQLite Viewer	2.92	2.75	2.75	2.75	2.83	100%

Table 6

Functional and didactic criterion and its indicators in the selection of CBT for teaching the database basics

The organizational criterion characterized the use of CBT for teaching the database basics from a technical point of view. Its indicators were as follows:

- *accessibility* – at the same time, the presence of a free version of the CBT for teaching the database basics and the validity period of the free version of the CBT were checked;

- *confirmation of the financial viability of the user* – characterized the absence in the CBT of personal data on the financial situation of the user for the subsequent collection of funds for the use of this tool;

- *ease of use* – characterized the convenience and understandability of the CBT interface for use in teaching the database basics.

The results of the intermediate calculations of the expert survey by the organizational criterion are presented in Tables 7-9.

Expert number	The number of points by indicator			
	1a	**1b**	**2**	**3**
1	3	0	0	1
2	3	1	1	2
3	2	2	0	0
4	3	0	0	1
5	3	2	0	2
6	3	2	0	1
7	3	0	0	2
8	2	2	1	2
9	3	1	0	1
10	3	2	0	3
11	3	1	1	1
12	3	2	0	1
Average	2.83	1.25	0.25	1.42

Table 7

Google Cloud SQL CBT assessment by the organizational criterion

Expert number	The number of points by indicator			
	1a	**1b**	**2**	**3**
1	3	1	0	2
2	3	0	0	2
3	3	2	1	2
4	3	1	0	1
5	3	2	1	1
6	3	1	0	1
7	3	0	0	2
8	2	1	0	2
9	3	2	0	1
10	3	1	0	2
11	3	1	0	3
12	3	0	0	2
Average	2.92	1.00	0.17	1.75

Table 8

Microsoft SQL Azure CBT assessment by the organizational criterion

Expert number	The number of points by indicator			
	1a	**1b**	**2**	**3**
1	3	3	3	2
2	3	3	3	1
3	2	3	3	3
4	3	3	3	2
5	3	3	3	3
6	3	3	3	2
7	3	3	3	1
8	3	3	3	2
9	3	3	3	2
10	3	3	3	3
11	3	3	3	3
12	3	3	3	2
Average	2.92	3.00	3.00	2.17

Table 9

SQLite Viewer CBT assessment by the organizational criterion

Let us reflect the results on the indicators of the organizational criterion for each CBT for teaching the database basics (Table 10).

CBT for teaching the database basics	Indicators				Manifestation of the criterion
	1a	**1b**	**2**	**3**	
Google Cloud SQL	2.83	1.25	0.25	1.42	25%
Microsoft SQL Azure	2.92	1.00	0.17	1.75	50%
SQLite Viewer	2.92	3.00	3.00	2.17	100%

Table 10
Organizational criterion and its indicators in the selection of CBT for teaching the database basics

Let us recall that an indicator is considered positive if the arithmetic average of the indicated indicator points is greater than 1.5. Below is the final table of the results of the manifestation of all the criteria for the selected CBT for teaching the database basics (Table 11).

CBT for teaching the database basics	CBT database criterion	
	Functional and didactic	Organizational
Google Cloud SQL	100%	25%
Microsoft SQL Azure	100%	50%
SQLite Viewer	100%	100%

Table 11
The results of the manifestation of all the criteria in the selected CBT

So, as a result of the expert assessment of the selected CBT for teaching the database basics to the students at higher education institutions, the best results for use were shown by SQLite Viewer.

Discussion

The introduction of CBT allows training subjects to obtain installed and configured software for working with databases. The main advantages of using the CBT for teaching the database basics at higher education institutions are as follows: high scalability (workload is constantly monitored), reduced software purchase costs (DBMS), speed of service delivery, reliability and security from the cloud computing provider.

Let us consider the possibilities of applying the considered CBTs to teaching the basics of database in the preparation of students of higher education institutions.

Google Cloud SQL is a CBT made by Google, created on the Google Cloud platform for working with MySQL DBMS. This tool makes it possible to create, configure and use relational databases with users' applications based on App Engine applications written in the Python programming language[11].

The main features of this CBT:

[11] N. Sabharwal y S. Gupta, Working with CloudSQL. In Hands on Google Cloud SQL and Cloud Spanner (Berkeley, CA: Apress, 2019).

- ease of use – the presence of a rich graphical user interface and the ability to create, form, manage and control databases;

- a fully managed service – no need to worry about replication, tuning, and other similar tasks when working with the database, all this is done by the service;

- high availability – the service remains available, even if the data center becomes unavailable;

- ensuring database data protection – data records in the Google server database are encrypted, therefore access is allowed only from authorized IP addresses and occurs through the SSL protocol[12].

To conduct a training course on the basics of databases, it is possible to create a database for each student, using which he/she can carry out the practical tasks of the teacher. The latter has information on the status of the work of all students and can carry out a check at any time. The possibilities of linking accounts to the Google Cloud SQL project can also contribute to more convenient and faster remote learning of DBMS technologies. This CBT has a limited validity period for the free version. Therefore, the higher education institution must acquire a license for full use.

Microsoft SQL Azure is a CBT made by Microsoft, hosted on the Microsoft Azure platform. SQL Azure is a projection of the traditional Microsoft SQL Server DBMS onto the cloud, which allows working with a database. This CBT makes it possible to store structured and unstructured data, execute relational queries, and also provides functionality for searching, creating analytical reports, integrating and synchronizing data. SQL Azure has a high level of security with built-in data protection, self-healing and backup system[13].

Working with SQL Azure is built on the basis of three mechanisms – personal account, server and database. An account is the owner of one or more servers. A server is a logical concept similar to Master DB, which has one or more databases, contains metadata about the database and data on its use. Each database within the server stores standard SQL objects: users, tables, indexes, and more. For this CBT, the validity period of using the free version is limited. Therefore, the higher education institution must acquire a license to use it in full[14].

SQLite Viewer is a CBT that is synchronized with Google services, which allows opening and managing SQLite databases. To use SQLite Viewer in teaching the database basics, the teacher and student need:

[12] Z. A. Bulinsh, “Migratsiya baz dannykh MySQL v oblachnuyu sredu Google Cloud SQL i vozmozhnosti ee primeneniya v sfere obrazovaniya”, Obrazovatelnye tekhnologii i obshchestvo, Vol: 15 num 3 (2012): 554-560.

[13] L. G. Lobel, E.D. Boyd. Microsoft® Azure™ SQL Database Step by Step Redmond (Washington: Microsoft Press, 2014).

[14] A. Sleit; N. Misk; F. Badwan y T. Khalil, “Cloud Computing Challenges with Emphasis on Amazon EC2 and Windows Azure”, International Journal of Computer Networks & Communications (IJCNC), Vol: 5 num 5 (2013): 35-44.

1. Add the SQLite Viewer service to one's own Google account through any browser (Chrome, Firefox, etc.).

2. Log in to one's Google Account.

3. Go to the Google Drive service.

4. Click the "Create" button, select "SQLite Viewer".

5. After opening the SQLite Viewer web page, download the SQLite database file for viewing and working with it from Google Drive or from a computer.

In SQLite Viewer, one can open, view, and edit SQLite database files. This service has the ability to execute various commands for working with tables (for example, create, delete) and records (for example, add, edit, delete, select) of database tables that are created in the SQLite DBMS[15].

Basic commands for users are as follows: creating database files; creation, definition of field types, filling, editing and deleting tables; creating, defining, and deleting indexes; viewing, editing, adding and deleting records; search for records; import and export records to a text file; import and export tables from/to CSV files; import and export of a database from/to SQL files; creating SQL queries and the like[16].

SQLite is a free open source relational DBMS, a visual tool for creating, designing and editing database files. That is why teachers at higher education institutions have the opportunity to use the specified CBTs for free in educational activities.

Conclusions

According to the research goal, the method of expert evaluation was applied, which consisted of two stages: in the first stage, a survey of experts was carried out to select the main CBT for teaching the basics of the database; in the second stage, the CBT was defined with respect to the selected selection criteria, which was advisable to implement in the teaching of the database basics at a higher education institution.

The study identifies the criteria and relevant indicators for the selection of the means of teaching students the database basics. As a result of expert evaluation, it has been found that, from the point of view of the manifestation of all criteria, the most appropriate CBT for teaching the database basics to the students of higher education institutions is SQLite Viewer. Thus, the hypothesis of the study has been confirmed that the introduction of CBTs into the educational process of teaching the basics of databases is necessary on the basis of compliance with the functional and didactic and organizational criteria.

A promising area of further research is the development of methodology for using the CBT for teaching the database basics to students of higher education institutions.

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