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The selection of cloud services for ER-diagrams construction in IT specialists databases teaching

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Abstract. One of the main aspects of studying databases in higher education institutions by future IT specialists is database design and software product development. This, in turn, is the most important problem of the developer's interaction with the customer. To facilitate the process of database design, ER-diagrams are used, which are based on the concepts of "Entity" and "Relationship". An ER diagram allows you to present a database in the form of visual graphical objects that define a specific subject area. The article considers the available cloud services for the construction of ER-diagrams for learning databases of future IT specialists and their selection the method expert evaluation. For this purpose, the criteria and indicators for the selection of cloud services for the construction of ER-diagrams of databases by future information technology specialists have been determined. As a result, it was found that the cloud services Dbdesigner.net and Lucidchart are the most convenient to learn. It is determined that for a teacher of a higher education institution the use of cloud services is an opportunity to use licensed software in education without additional costs.

Keywords: selection, cloud services, ER-diagrams, databases, future specialists in information technology, future IT specialists

1. Introduction

One of the main aspects of studying the discipline "Databases" in higher education institutions by future information technology specialists is database design and soft-ware product development, which in turn is the most important problem of interaction between the developer and the customer. While studying it, students should realize that the task of the developer is to reproduce the wishes of the customer as accurately as possible by developing a database management software product. Therefore, the main problem that future IT professionals need to learn to solve is the correct construction of a database diagram. To do this, future developers must study in detail the subject area of the database and make the requirements of the customer. The result

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of this work should be a database that is clear and that most accurately reflects the problem to be solved and does not contain redundant data.

To facilitate the database design process, ER charts are used, which are based on the concepts of "Entity" and "Relationship". ER diagram allows you to present a data-base in the form of visual graphical objects that define a specific subject area.

1.1. Analysis of recent research and publications

Many scientific papers are devoted to database theory (DB), database normalization processes, database design methodology, database architecture, consideration and description of modern DBMS, SQL query language, etc.

Dowming Yeh and Yuwen Li and William Chu investigated the possibilities of extracting the diagram of the relationship of the entity from the table of an outdated database [30].The author's proposed new approach uses the display forms, table schema, and instances as a database reverse engineering input [30].

Paul Schmieder, Beryl Plimmer, Gillian Dobbie consider the possibilities of computer tools for building sketches for informal sketching and automatic conversion into official submissions [19]. At the same time, the authors consider the InkKit charting tool with domain semantics for successful recognition and automatic conversion of entity-relationship diagrams [19].

Another group of authors (P. S. Dhabe, M. S. Patwardhan, Asavari A. Deshpande, M. L. Dhore, B.V. Barbadekar and H. K. Abhyankar) considered the Articulated Entity-Relationship, which was considered an extension of the Entity-Relationship diagram. The researchers considered these types of diagrams as an integral part to fully automate normalization in the case of placing information about functional dependence [3].

A group of authors (Xiong Jing, Liu Yong-ge, Gao Feng, Wang Ji-peng) analyzed the similarities between the model of entity relationships and the model RDF (model for representing named properties and property values), also, proposed ideas and processes of transformation. The researchers also implemented the Oracle Bone Inscriptions ontology using a transformation method that requires manual intervention during the transformation process [9].

Other scientists (Alexander L. Hayes, Mayukh Das, Phillip Odom and Sriraam Natarajan) have proposed a convenient automatic construction of background knowledge by constructing a mode from ER diagrams. The authors have developed a graphical user interface that allows a domain expert to interact with the system using entity relationship diagrams used to build modes for the learning system [8].

Cloud technology has been studied by many scientists [10–12, 14, 15, 20, 25]. In particular, Albert A. Azaryan, Kateryna P. Osadcha, Viacheslav V. Osadchyi, Svitlana V. Symonenko, Svitlana O. Sysoieva, investigated cloud technologies for enhancing communication of IT professionals [24]. Nataliya O. Kushnir, Viacheslav V. Osadchyi, Nataliia V. Valko considered cloud technologies for STEM education [28], Svitlana L. Proskura and Svitlana H. Lytvynova considered the approaches to Web-based education of computer science bachelors in higher education institutions [16]. Oksana M. Markova, Serhiy O. Semerikov, Andrii M. Striuk, Hanna M. Shalatska, Pavlo P. Nechypurenko and Vitaliy V. Tron investigated the implementation of cloud service models in training of future information technology specialists [15].

However, the question of appropriate selection of cloud services for the construction of

ER-diagrams for training databases of future information technology professionals has not been explored, so this will be the purpose of this article.

2. Methods of the study

Methods of analysis and generalization were used to determine the criteria and indicators for the selection of cloud services.

To determine the most important cloud services for the construction of ER-diagrams of databases that can be used in the educational process of future specialists in information technology, the method of expert evaluation was used [22, 26].

Experts were involved in this method twice. The first stage of involving experts was to determine the most effective cloud services for building ER-diagrams of databases. At this stage, experts and teachers of higher education institutions were involved as experts, which in one way or another are related to the database learning of IT specialists (17 people).

For consideration by ranking experts, 12 different cloud services were proposed to build ER-diagrams of databases that can be used in the training of databases of future information technology professionals.

Experts were offered a scoring system [22, 26], according to which for N services the value of N is given to the most important in use, 1 – to the least important.

The main parameter for assessing significance is its total rank S, which is calculated by the formula [22, 26]:

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

where S_j is the total rank of the j-th indicator; $j = 1, 2, 3, \ldots, n$; n is the number of indicators; m – number of experts; $R_{i,j}$ – the rank of the j-th indicator, determined by the i-th expert.

Besides, to determine the level of agreement between experts, it is necessary to calculate the Kendell concordance coefficient W [22, 26], which determines whether such total ranks are objective, and it is calculated by the formula:

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

where:

$$d_j = S_j - 0.5 \cdot m(n+1), \tag{3}$$

$$S(d^2) = \sum_{j=1}^{n} d_j^2, \tag{4}$$

After the calculations, if the value obtained differs significantly from zero, it indicates that there is an objective agreement between the experts and therefore the total rankings are quite objective.

The second stage of involving experts was to select the most important cloud services for building ER-diagrams of databases according to certain criteria and indicators. At this stage, 15 respondents were involved to test the manifestation of each of these criteria for each of the selected cloud services to build ER-diagrams of databases.

At this stage, respondents were asked to evaluate all indicators for each criterion. Evaluation of indicators was proposed to be carried out on a well-known scale [22, 26] from 0 to 3. As a result, the indicator was considered positive if the value of the arithmetic mean of its parameters was not less than 1.5.

The degree of manifestation of the criterion was determined by the following scale: if 76% – 100% of its indicators are positive, the criterion is characterized by the high expression, 56% – 75% – sufficient manifestation, 50% – 55% – critical manifestation, if less than 50% of its indicators were positive – the criterion is considered insufficiently manifested.

3. Results

To build an ER-diagram of the database at the logical and conceptual levels, we propose to use cloud services. Such tools help to design a database to better form the ideal data structure according to customer needs.

We share the opinion of Mariia P. Shishkina and Maiia V. Marienko, who note that cloud services are used to provide the user with electronic educational resources, as well as to ensure the processes of creation and supply of educational services [21].

The use of cloud services in the training of future specialists in information technology opens the way to individualization of learning, interactive interaction, and active cooperation between participants in the educational process.

Consider in detail the available cloud services for building ER-diagrams of databases. Note that we will consider completely free services or those that have a free tariff plan, but with some limitations of functionality.

Erwin Data Modeler [6] is a cloud service that allows you to create a logical data model. This service can be used free of charge in the educational process to train specialists in information technology. The main characteristics of this service include: providing centralized management of data models; cooperation with other users; simple graphical interface; automatically compares models and databases; effective synchronization of direct and reverse code design, etc.

Cloud service **SQL DBM** [23] (figure 1) in the free plan allows you to create only 1 project. This service has a clear interface for building ER-diagrams of databases, which allows you to easily manage both large and small databases; import an existing database schema; add tables, keys, indexes, constraints, links, etc to an existing ER chart; copy or move columns between tables; share the project with other users, and in the settings, there is a function to increase or decrease the chart, change the screen theme (dark, light), etc.

Toad Data Modeler [17] – this cloud service can be used for free for 30 days. It is designed for data modeling, which maximizes performance through high automation, transparent workflows, and built-in functionality. This service is characterized by:

- speed of access to key data,
- the ability to export the chart to an Excel file,

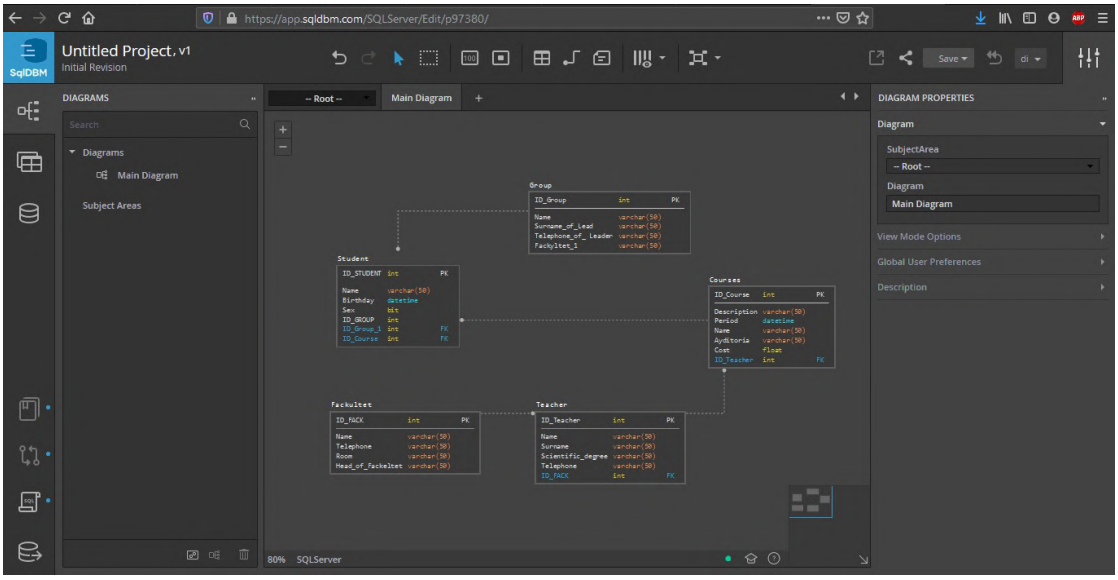

Figure 1: SQL DBM cloud service.

- ease of finding differences, comparing and synchronizing data and diagrams,
- saving the rollback of transactions directly from the transaction log without the need to restore from a backup,
- powerful query customization capabilities,
- ensuring the execution of scripts and fragments of T-SQL for multiple instances and servers,
- automatic rewriting and optimization of queries, etc.

Gen My Model [7] – cloud service for building ER-diagrams of databases, supports Archi Mate (architecture modeling language) and BPMN (business process model and notation system), has a centralized storage model that allows you to simultaneously simulate collaboration. It allows you to manage versions and access rights; import or export PDF documents, etc.

Valentina [27] is a cloud service for creating, administering MySQL, PostgreSQL, SQLite, and MariaDB databases, which allows you to add or remove users, manage rights, view live logs, and run diagnostics. Its main characteristics can be considered:

- editing ER-diagrams of databases,
- providing special forms of Valentine to work with data,
- view and print Valentine's reports,
- SQL query management,
- diagnostics, defragmentation, re-indexing, data storage, and compression, etc.

Lucidchart [13] – this cloud service combines the construction of diagrams, data visualization, and collaboration, simplifies the process of drawing diagrams and charts (figure 2). This service contains samples and examples of block diagrams, UML models, ER models, and business process

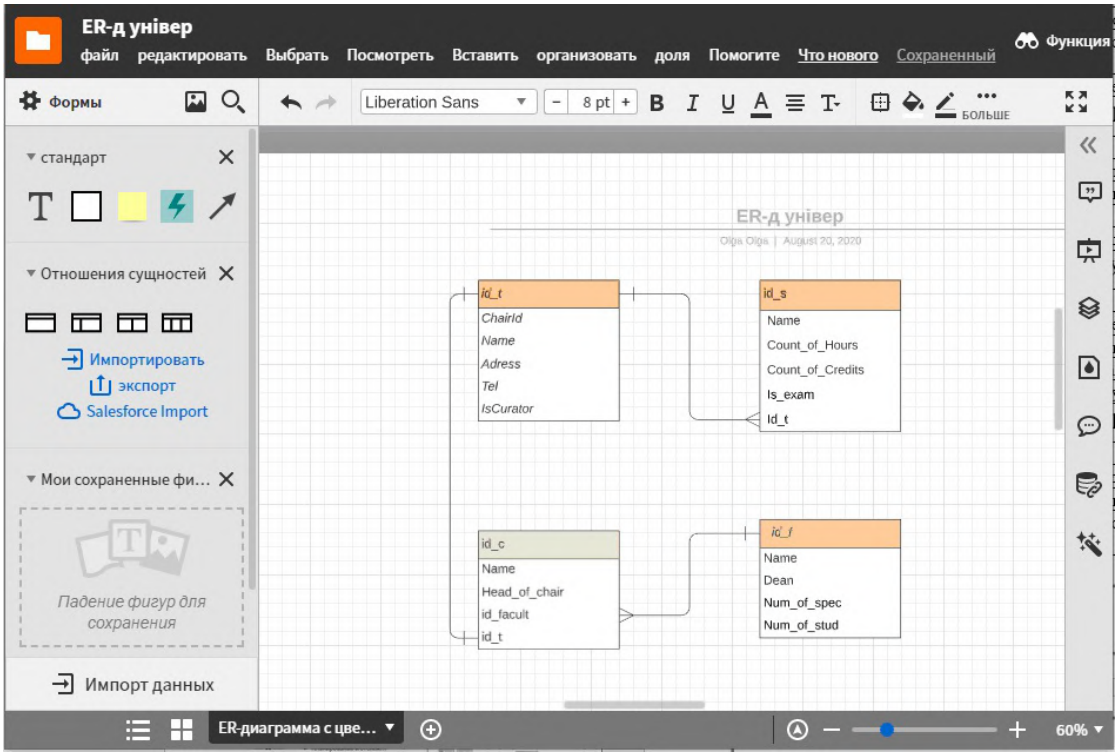

Figure 2: Lucidchart cloud service.

models, frameworks/layouts, system diagrams, organizational charts, connection diagrams, and sites.

This service is characterized by:

- export the edited database schema to SQL and transfer it from Lucidchart to the database at the user's choice,
- support for the most common DBMS platforms, including MySQL, Oracle, PostgreSQL, and SQL Server,
- intuitive interface,
- import and export of Microsoft Visio documents,
- conversion of results into PDF, JPG, PNG,
- ready-made templates and forms,
- quick addition or merging of objects,
- adding images;
- adding schemes to blog or wiki pages,
- version control with preservation of previous developments,
- group chat,
- post-it comments;
- distribution of images and samples, etc.

The free version includes the creation of 3 documents (up to 60 objects per document), access to a limited set of ready-made templates, as well as available integration with the disk, documents, spreadsheets, presentations, and e-mail from Google and Microsoft.

In the free plan of the cloud service, **Creately** [1] can create 5 documents, 1 folder, and collaborate with 3 users. It features a variety of schematic tools, a powerful context interface, smart objects, and special tools that help you draw charts fairly quickly compared to other services. This service allows you to build charts, site maps, organizational charts, UML charts, network charts, SWOT analysis charts, connection maps, business process models, and more.

The functionality includes: establishing joint work between users, creating joint projects, adding comments when working in a team, the ability to share charts with other users, monitoring of project changes.

Each change is saved, but the user can easily revert to previous versions of documents. The service has a large library of forms and templates, offers unlimited possibilities and different types of charts and visual effects, export charts to PDF, JPG or PNG, image import, Drag & Drop support, offers work with JIRA, Confluence, GoogleApps, and more.

Dbdesigner.net [2] is a cloud service that allows the user to create 2 database models with 10 tables in each for free. Its main characteristics include: user-friendly interface for designing the database structure; joint work on projects and their exchange; function of importing an existing database or creating it from scratch; export of the created diagram of a DB in PNG and PDF formats; generation of SQL-scripts for any of the following databases: MySQL, MSSql, PostgreSQL, Oracle, SQLite, etc.

The **QuickDBD** [18] cloud service can be used free of charge to create 1 model from 10 tables. The service allows users to share their charts on the Internet using a URL, creating it in the form of images, PDF, and SQL; build a database chart.

Vertabelo [29] is a cloud service for the visual design of basic data, supports the following basic data: PostgreSQL, MySQL, Microsoft SQL Server, SQLite, Oracle, IBM DB2, and HSQLDB. It allows you to create a model of basic data simply by graphically drawing tables. The features of this service include checking the model that is created at each stage and providing tips on how to improve it.

At any time, you can see the SQL preview that will be generated for the selected item. It is also possible to share your baseline models at three different levels of access: Owner, Editor, and Viewer. In this service, when working together, it is possible only one user to edit the model, for others it is read-only, everyone can see the changes in the model immediately after an autosave.

If the user wants to share the model with other users, but they do not want to create Vertabelo accounts, it is possible to create a public link to the model or send it via e-mail. Thus, there is a visualization of the database data structure and joint work on it.

Vertabelo cloud service is fully accessible to students, teachers, and non-profit organizations, provided that it is used only for educational or non-profit purposes.

DModelAid [4] – this cloud service allows you to build 1 model for free, consisting of less than 11 tables, designed to document the design of the basic data in the form of an interactive diagram.

Characteristic features of this service are:

- allows you to visualize tables with keys, indexes, and links,

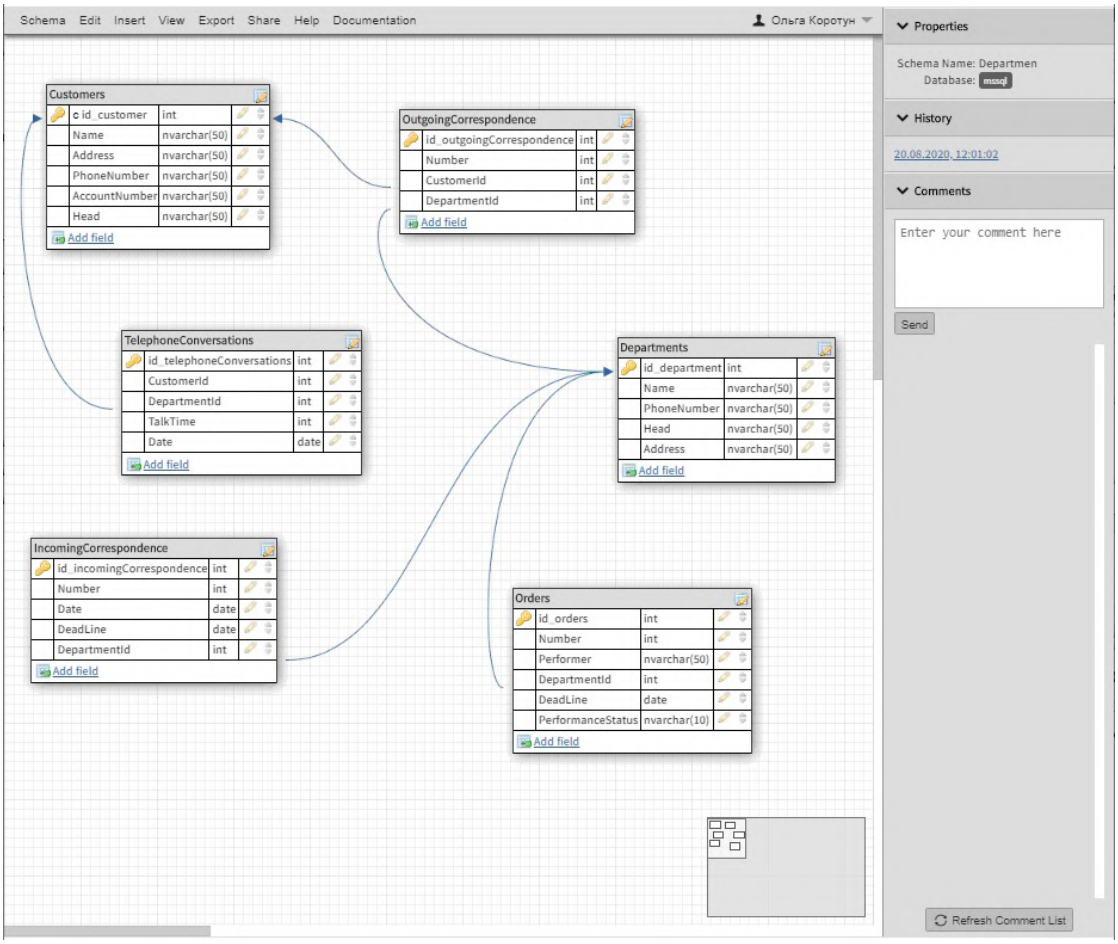

Figure 3: Dbdesigner.net cloud service.

- supports keyboard shortcuts for easy access,
- automatically documents the created database project,
- perform physical design using the following databases: Microsoft SQL Server, Oracle, MySQL, SQLite, MS Access,
- supports SQL queries,
- allows you to export a script from a project to create physical databases,
- change the database at any time, and it will be correlated with the data type and so on.

Draw.io cloud service [5] is free to develop charts, allows you to easily create and manage them. Its main characteristics include:

- storage of the built model in various formats,
- creation of a wide range of database diagrams, including UML diagrams, ER diagrams, etc.,
- availability of templates for database design,

- joint work,
- display relationships between tables using different shapes and arrows,
- export of database diagrams in the form of images, PDF, HTML, XML, etc.

At the first stage of the expert evaluation method, the experts were offered a survey, which proposed to rank the following cloud services to build ER-diagrams of databases: 1) Creately; 2) Dbdesigner.net; 3) DModelAid; 4) Draw.io; 5) ErwinDataModeler; 6) GenMyModel; 7) Lucidchart; 8) QuickDBD; 9) SQL DBM; 10) ToadDataModeler; 11) Valentina; 12) Vertabelo.

According to the results of the survey, the relevant data on the ranking of the proposed cloud services for the construction of ER-diagrams of databases were obtained (see table 1).

Table 1
Ranking of cloud services for building database ER-diagrams

expert|service	1	2	3	4	5	6	7	8	9	10	11	12
1	3	12	7	6	11	1	10	2	9	5	4	8
2	4	11	6	3	12	8	9	5	10	1	2	7
3	1	9	6	7	10	4	11	8	12	3	2	5
4	8	10	5	6	9	7	12	3	11	1	2	4
5	6	11	2	1	10	4	12	5	9	8	7	3
6	3	12	7	6	11	1	10	2	9	5	4	8
7	4	7	6	3	8	12	9	5	10	1	2	11
8	1	9	6	7	10	4	11	8	12	3	2	5
9	8	10	5	6	9	7	12	3	11	1	2	4
10	6	11	2	1	10	4	12	5	9	8	7	3
11	3	8	7	6	11	1	10	2	9	5	4	12
12	4	11	6	3	12	8	9	5	10	1	2	7
13	1	9	6	7	10	4	8	11	12	3	2	5
14	8	10	5	6	9	7	12	3	11	1	2	4
15	6	11	2	1	10	4	12	5	8	9	7	3
16	3	12	7	6	11	1	10	2	9	5	4	8
17	4	11	6	3	12	8	9	5	10	1	2	7
S	73	174	91	78	175	85	178	79	171	61	57	104
d	-37.5	63.5	-19.5	-32.5	64.5	-25.5	67.5	-31.5	60.5	-49.5	-53.5	-6.5

According to the results of the survey, the following cloud services were selected: Dbdesigner.net, ErwinDataModeler, Lucidchart, SQL DBM.

Based on experimental data (see table 1), we calculate the Kendell concordance coefficient according to formulas (1) – (4). As a result, we have $W = 0.64$. Since W differs significantly from 0, there is an objective agreement between the experts and the total ranks are fairly objective.

The analysis of the available cloud services for the construction of database charts allowed to identify the following criteria and relevant indicators for the selection of cloud services for the construction of ER-charts of databases:

1) `design-didactic`: integration of different technologies for creating databases (1.1); model for a DB (1.2); setting up SQL queries (1.3); collaboration (1.4); key fields and links (1.5); the final view of the database schema (1.6);

2) `technological`: access rights (2.1); availability of templates (2.2); communication capability (2.3); cloud data storage (2.4); free of charge (2.5);
3) `functional`: import of existing database diagrams (3.1); project settings (3.2); version control (3.3); export to various formats (3.4).

The **design-didactic criterion** characterizes the service for designing ER-diagrams of databases and its didactic component:

- The indicator "integration of different technologies for creating databases" provides for the creation of charts for the following databases: MSSQL, MySQL, PostgreSQL, SQLite, NoSQL, etc.
- The indicator "model for a DB" provides the ability to automatically create a chart based on an existing database.
- The indicator "setting up SQL queries" characterizes the ability to generate an SQL script.
- The indicator "collaboration" provides an opportunity to work together on the project, which is the basis of project work for future professionals in information technology.
- The indicator "key fields and links" characterizes the ability to identify key fields and establish relationships between tables.
- The indicator "the final view of the database schema" characterizes the appearance of the final diagram of the database, its readability, and intelligibility.

The resulting data on the indicators of design-didactic criteria for each of the selected cloud services for the construction of ER-diagrams of databases contains table 2.

Table 2
The design-didactic criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	1.1	1.2	1.3	1.4	1.5	1.6	Manifestation of the criterion
Dbdesigner.net	2,13	1,13	1,87	2,73	2,60	2,40	high
ErwinData Modeler	1,47	2,53	1,47	2,53	2,87	1,87	sufficient
Lucidchart	1,80	2,73	0,53	2,40	2,40	2,60	sufficient
SQL DBM	2,53	2,13	2,07	0,93	2,47	2,67	high

The **technological criterion** characterizes the technical capabilities of cloud services for the construction of database diagrams, and includes the following indicators:

- "Access rights", which provides access to the created database diagram at different levels.
- "Availability of templates", which characterizes whether this service has ready-made templates for quick creation of a database diagram.
- "Communication capability" means the ability to chat with other users who have accessed this chart.
- "Cloud data storage" characterizes the ability to store the created charts in the data warehouse.
- "Free of charge" means free access to the cloud service or its specific functionality.

Table 3
The technological criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	2.1	2.2	2.3	2.4	2.5	Manifestation of the criterion
Dbdesigner.net	1,73	2,07	0,73	2,40	2,53	high
ErwinData Modeler	1,33	1,27	1,93	1,27	1,87	Insufficient
Lucidchart	1,73	2,47	2,87	2,47	2,67	high
SQL DBM	1,00	0,53	0,53	1,60	1,67	Insufficient

The resulting data on the indicators of the technological criterion for each of the selected cloud services for the construction of ER-diagrams of databases are contained in table 3.

The **functional criterion** characterizes the available functionality of the cloud service for building ER-diagrams of databases. Consider in detail all the indicators of this criterion.

- The indicator "import of existing database diagrams" provides the ability to import an existing database diagram and the ability to refine it.
- The "project settings" indicator provides the ability to change project settings, such as copying or moving columns between tables, viewing only table names or only keys, and more.
- The "version control" indicator provides an opportunity to compare different versions of the constructed diagrams to one DB.
- The indicator "export to various formats" provides the ability to present the results of work in the cloud service in various formats, including pdf, jpg, png, etc.

The resulting data on the indicators of the functional criterion for each of the selected cloud services for the construction of ER-diagrams of databases are contained in table 4.

Table 4
The functional criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	3.1	3.2	3.3	3.4	Manifestation of the criterion
Dbdesigner.net	2,00	1,67	2,13	2,47	high
ErwinData Modeler	1,53	2,47	1,87	1,07	sufficient
Lucidchart	2,73	2,60	0,53	1,73	high
SQL DBM	2,40	1,53	0,60	0,60	Insufficient

The generalized results are presented in table 5.

Thus, as research shows, the most convenient and high-quality tools among cloud services for building ER-diagrams of databases on the manifestation of all criteria were Dbdesigner.net and under certain conditions Lucidchart.

These services allow you to quickly and efficiently design a database based on the built ER-diagrams, which in turn are used for research and development of software and information systems for business.

Table 5
Generalized results of the selection of cloud services for the construction of ER-diagrams of databases on a display of all criteria

Service | Criterion	Design-didactic	technological	functional
Dbdesigner.net	high	high	high
ErwinData Modeler	sufficient	Insufficient	sufficient
Lucidchart	sufficient	high	high
SQL DBM	high	Insufficient	Insufficient

4. Conclusions

Therefore, the construction of ER-diagrams of databases by future IT professionals is convenient to do using cloud services for the purpose, which significantly speeds up the process, as it saves time (does not require installation, configuration, and upgrade), allow students to work in pairs and small groups, in free versions there is enough functionality for training.

Criteria and indicators for the selection of cloud services for building ER-diagrams of databases by future information technology specialists have been determined, according to which it has been established that the services Dbdesigner.net and Lucidchart are the most convenient to learn. For a teacher of higher education, the use of cloud services is an opportunity to use licensed software in education at no additional cost.

Thus, the importance and timeliness of the introduction of such services in the training of databases of future information technology professionals will help improve the educational process of the discipline “Databases”.

Prospects for further research see the study of the use of selected cloud services in the educational process and their impact on the formation of professional competencies of students.

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