The use of MOOCs as additional tools for teaching NoSQL in blended and distance learning mode

View the article online for updates and enhancements.

The use of MOOCs as additional tools for teaching NoSQL in blended and distance learning mode

I S Zinovieva[1], V O Artemchuk[2,3], Anna V Iatsyshyn[3], Y O Romanenko[4,5], O O Popov[2,3,4], V O Kovach[3,5], D V Taraduda[6] and Andrii V Iatsyshyn[2,3]

[1] Kyiv National Economic University named after Vadym Hetman, 54/1 Peremohy Ave., Kyiv, 03057, Ukraine

[2] G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine, 15 General Naumova Str., Kyiv, 03164, Ukraine

[3] State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine", 34a Palladin Ave., Kyiv, 03680, Ukraine

[4] Interregional Academy of Personnel Management, 2 Frometivska Str., Kyiv, 03039, Ukraine

[5] National Aviation University, 1 Liubomyra Huzara Ave., Kyiv, 03058, Ukraine

[6] National University of Civil Defence of Ukraine, 94 Chernyshevska Str., Kharkiv, 61023, Ukraine

E-mail: `ira.zinovyeva@kneu.edu.ua, ak24avo@gmail.com, anna13.00.10@gmail.com`

Abstract. Today there is a significant demand for improving the quality of the educational process in higher education institutions, in particular, through the improvement of principles and methods of teaching various sciences by enhancing the practical skills of students and graduate students. The implementation of this task is particularly difficult in the context of distance learning (for full-time and part-time) and blended learning. This study corresponds to the current direction, as it concerns the study of the possibilities and feasibility of using additional tools for teaching disciplines within NoSQL. Paper's focus is on the justification of the use as an additional tool of a number of massive open online courses (MOOC) distance learning platforms, a comparative analysis of a number of platforms for their compliance with the established criteria. Examples of using MOOC MongoDB University within the discipline "Organization of NoSQL databases" are given. To confirm the facts of the expediency of using MOOC as an additional tool in blended learning and distance learning mode, the data of the survey of students are presented.

1. Introduction

Modern university science in Ukraine is aimed at training highly professional specialists in various fields, developing the scientific potential of the country through the formation of relevant competencies of applicants at I–III levels of higher education, creating conditions to ensure the possibility of "lifelong learning" for effective self-realization. The basis of the modern paradigm of higher education is the need to form a culture of intellectual activity, which, among other things, involves: the acquisition of skills and abilities to adapt to the external environment and the changes that occur in it; development of the innovative type of thinking; the desire to learn. The above is relevant for both applicants for higher education and institutions that provide educational services.

The reality of recent years is that the need to transform the ways and methods of organizing the educational process has become a challenge for all, without exception, higher education institutions (HEIs) around the world. The transition to distance learning [1–3], and later – blended learning [4, 5], has given impetus to the active development in the market of various educational platforms, software for organizing conferences, platforms for storing educational content and video hosting, etc. In addition, it became clear that the organization of the educational process in distance mode or blended form requires not only the availability of appropriate software and hardware resources but also requires consideration of the specifics of training higher education, including specialties and educational qualifications, specifics of educational-professional (educational and scientific) programs, the profile of HEIs, the expected learning outcomes.

The study of databases (DB) is a mandatory component of the training of specialists in various specialties and fields of knowledge in the context of the concept of Industry 4.0. Databases are part of a number of digital technologies, such as mobile applications [6], GIS [7], multimedia [8], Grid and Smart technologies [9], Artificial Intelligence [10], etc. According to Complete Ranking, prepared by DB-Engines [11], in December 2020 the most common DB in the world were (by rating's place): 1) Oracle, 2) MySQL, 3) Microsoft SQL Server, 4) PostgreSQL, 5) MongoDB, 6) IBM Db2, 7) Redis, 8) Elasticsearch, 9) SQLite, 10) Cassandra. From the presented list 6 objects belong to the Relational DB class, and 4 – NoSQL (MongoDB, Redis, Elasticsearch, Cassandra), and NoSQL databases show the upward dynamics of popularity for the last few years in a row, as shown in figure 1.
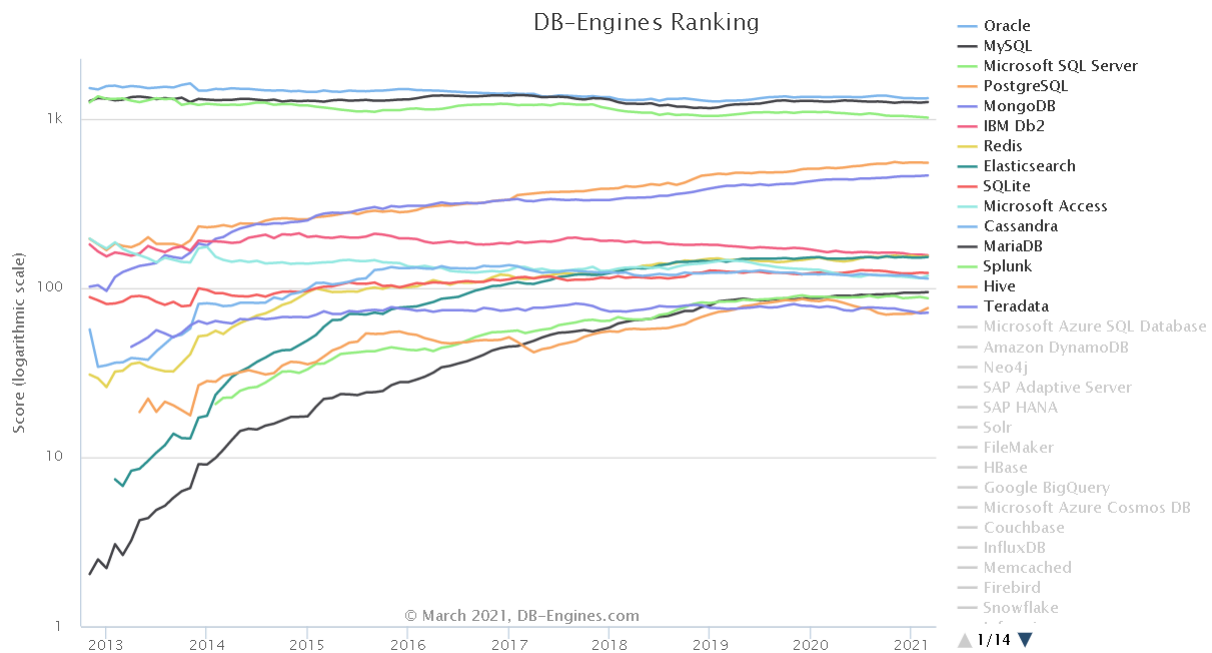

Figure 1. World popularity rating of modern databases according to DB-Engines [12].

For example, the familiar platform for distance learning Moodle [13] can work on the basis of database servers such as MySQL/MariaDB, MongoDB, PostgreSQL, CouchDB, Microsoft SQL Server [14].

These data show that NoSQL databases are important in the IT market, as the modern digital world and modern technologies, for the most part, require the operation of large amounts of unstructured data, support for simultaneous operation of a large number of users, horizontal

scaling, application of cloud technologies, ensuring a high level of performance, fault tolerance and reliability [15]. Changes in global trends in IT and databases, in particular, require constant updating of curricula of free economic zones and research institutions to prepare students and graduate students, especially for specialties whose future professionals must master the professional competencies of working with NoSQL databases. In addition, given the current challenges to the higher education system, it is necessary to change approaches to teaching disciplines related to the study of NoSQL databases, in the direction of using a wide range of software tools to improve the quality of teaching in distance learning and blended learning, which is confirmed by the results of the study presented below.

2. Literature survey

The issue of the introduction of modern digital technologies in the educational process of HEIs and research institutions, which increase motivation to study, stimulate students and graduate students to acquire new knowledge and skills, is not new, but now – is quite common and relevant. Various aspects of the application of digital technologies in the training of students and spirants are described in [16–26] and others papers.

Thus, in recent publications [27–33] more and more often the subject of consideration are the problems of effective organization of various learning technologies (e-Learning, mobile learning, blended learning) using online tools, analyze the possibility of transition to specialized platforms for distance learning (Moodle, Google Classroom, iSpring Online, etc.), evaluates the feasibility and effectiveness of their use.

Given the level of penetration of online tools into the learning process are distinguished (by model): traditional, distance, and blended learning [34]. If earlier scientific discussions revolved around the expediency or inexpediency of distance education in the practice of HEIs and research institutions, then, in a global pandemic, blended learning has become a new norm of teaching and learning around the world [35, 36]. In particular, the study [37] emphasizes that in comparison with exclusively traditional or exclusively distance learning, blended – shows greater effectiveness because it combines the best features of the previous ones. The use of modern online tools for blended learning allows to support the educational process 24/7, increases the involvement and motivation of students and graduate students, accelerates the development of professional competencies, and forms actual skills for the 21st century [38].

Regarding online technologies, the research of the author's team [39] gives grounds to identify the following key groups of such technologies:

- MOOC platforms (Coursera, edX, Codecademy, Udacity, Khan Academy, HTML Academy, etc.);
- learning management systems – LMS (Moodle, webTutor, iSpring, Canvas, Office 365, etc.);
- online programming judge systems – tools for organizing and supporting various competitions (competitions, quizzes, hackathons, etc.), such as UVa Online Judge, Google Code Jam, E-Olymp, etc.;
- online coding platform – tools for learning and honing knowledge of programming languages (Leetcode, Hackerrank, Freecodecamp, etc.);
- knowledge assessment tools – various platforms for assessment and testing (Classtime, Kahoot, Onlinetestpad, LearningApps, etc.);
- tools of online communication and video conferencing (Zoom, Google Meets, Skype, MS Teems, BigBlueButton, etc.).

As known, the platforms of Massive Open Online Courses (abbreviated as MOOC) are distance learning platforms that contain training courses, which usually include theoretical and practical components of future training, as well as tools for intermediate and/or final

control. The issue of improving the efficiency of the educational process in HEIs and research institutions using MOOC platforms, in particular, such as Coursera, edX, FutureLearn, is covered in [24, 40–55].

Features of design, architecture, query language SQL database, and the question of their use in the training of specialists in various specialties are considered in the following publications [16–19, 56–61].

In [56] the problem of using a cloud-oriented environment in the training of databases of future computer science teachers is investigated. The choice of cloud-based tools for training databases is substantiated. A model of using a cloud-oriented environment in database training has been developed. Guidelines are provided to teachers on the use of cloud-based distance learning systems, in particular Canvas in database learning.

The need to introduce into the curriculum of training specialists in various specialties of disciplines that study the principles of working with various databases NoSQL is emphasized in [62]. In this context, it seems interesting to experience the development of its own platform for the implementation of a distance learning system of students based on NoSQL databases (MongoDB, CouchDB) described in [14]. The purpose of this project was to provide engineering students the opportunity to combine practical and theoretical aspects of the study of NoSQL databases. The paper describes the mechanism of setting up the interaction of LMS Moodle and NoSQL databases, as well as the principles of implementation of training modules that allow you to interact with NoSQL DB in the framework of learning tasks on an interactive basis.

Analysis of the practice of distance learning, presented in [63], showed that the work of students on asynchronous platforms such as Moodle, Canvas, Blackboard Collaborate negatively affects the success of the learning process, as most information must be learned independently (without proper interactive interaction with the teacher). This gives grounds to talk about the feasibility of using a mixed form of organization of the educational process, which provides physical participation of the teacher in the learning process, in which lectures are held online, as well as part of practical and laboratory classes – online, where students can ask questions and get an answer right away. In addition, a number of studies [63, 64] emphasize the importance of a sound approach to the teacher's choice of online technologies and their inclusion in their training course. It is important to assess the current level of motivation of students (determine their expectations), to find out the basic technical skills of working with planned online tools to determine the necessary balance between the amount of asynchronous and synchronous work with students.

Based on the above, the purpose of this study is to substantiate the feasibility of using MOOCs as an additional learning tool in disciplines related to NoSQL DB in blended learning and full-time (part-time) higher education in distance learning.

3. Current work

NoSQL is a new generation of databases characterized by models and technologies of operation, different from traditional relational models. They arose as a reaction to the existing problems of traditional SQL databases. The term NoSQL refers to databases whose models are non-relational. Characteristic features of such DB are:

- Lack of SQL query language and mechanism to support transactions with ACID requirements. NoSQL databases support BASE requirements.
- Work in a distributed environment.
- Horizontal scaling.
- Ability to process aggregated, unstructured, non-normalized big data.
- Lack of rigid data storage schemes.

There is currently no clearly defined classification of these DBs. Most scientists agree that all NoSQL databases can be divided into four groups (according to the data organization model): Key/Value, Tabular Column-oriented, Document-oriented, and Graph Databases [65, 66]. Each of these data models is characterized by structural and technological features that should be introduced to students and graduate students. However, unlike relational models, the implementation of the same type of NoSQL database model can have significant technological features and even structural differences depending on the DBMS that supports it. This complicates the work of the teacher with its variability, does not allow to fully consider all aspects of working with NoSQL DB within the relevant course. Therefore, the study of a specific type of NoSQL DB must be supplemented, for example, by the use as an additional learning tool MOOCs platforms.

Indicative, in our opinion, is the experience of using MOOCs in the study of disciplines related to DB NoSQL in Kyiv National Economic University named after Vadym Hetman (or abbreviated – KNEU). In this HEI the discipline "Organization of NoSQL databases" [67] is taught at the first (bachelor's) level of higher education since 2018 and has undergone a number of evolutionary transformations in the context of the transition from traditional learning (2018/19 academic year) to distance (2019/20 academic year), and later blended learning and distance learning (2020/21 academic year), as shown in figure 2. In G.E. Pukhov Institute for Modeling in Energy Engineering of NAS of Ukraine prepares masters and graduate students in the specialty 122 "Computer Science" in the field of knowledge 12 "Information Technology". Therefore, the issue of updating the content and operational components of academic disciplines related to the design and study of databases is also relevant. The experience of KNEU on the use of MOOC in the training of future specialists by the authors of the article will be extended to various institutions, including National Aviation University, Interregional Academy of Personnel Management, National University of Civil Defence of Ukraine and State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine".
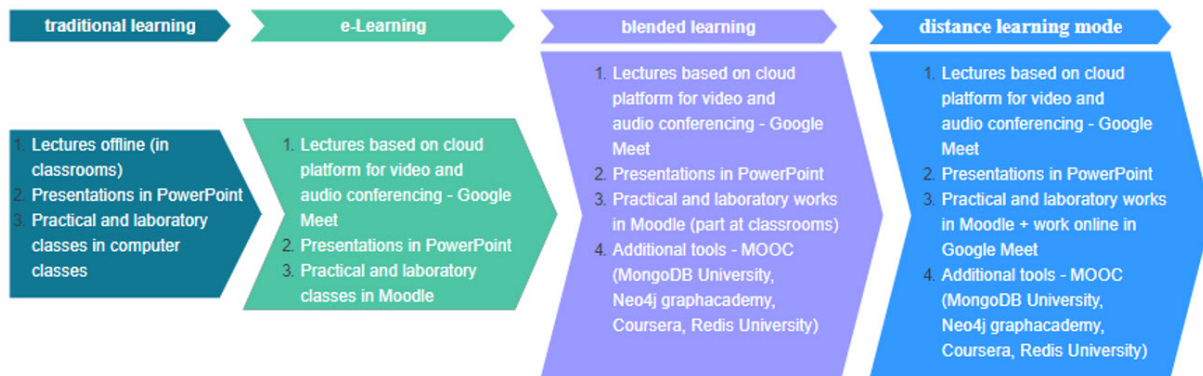

Figure 2. Transformation of the discipline "Organization of NoSQL databases" according to different models of learning organization.

At the stage of organizing the study according to the traditional scheme, the course included the presentation of educational material according to the standard scheme: lectures were conducted in class with a PC and a projector to present presentation materials; practical classes and laboratory work were held in computer classrooms (the teacher offered tasks, provided oral recommendations for implementation and instructions for laboratory or practical work).

The need to move to distance learning has forced teachers of the discipline to reconsider the principles of teaching the material and look for ways to provide work online. Yes, it was decided to use Google Meet as a tool for video communication of teachers, students, and graduate

students (KNEU has a corporate license for the G Suite for Education package).

Also, within the requirements for the implementation of the Order of the Rector of KNEU, the transition was made to the use of LMS Moodle as a basic platform for distance learning of full-time and part-time students of higher education.

In the current academic year, the approach to the organization of education was changed again, which was caused by the task of organizing blended learning for full-time and part-time higher education at all levels within the internal regulations of KNEU. The experience gained during the organization of e-Learning showed that the effectiveness of training has decreased. The reasons for this were a significant number of factors, among the main ones are stress from the emergency transition to e-Learning for both teachers and students; partial lack of technical skills in working with Moodle; unpreparedness of students for a high level of workload due to a significant amount of independent work and asynchronous mode of obtaining knowledge (communication with the teacher took place either during lectures or individually by e-mail or other means of communication). These aspects correlate with the results of studies [63, 64], covered in section 2 of this study. Given the experience gained, it was decided to conditionally adhere to the principle of "50/50" during the organization of blended learning, ie approximately 50% of the study time allotted for mastering the discipline should take place in synchronous mode – contact work, the other – in asynchronous. During September-October 2020, the work took place as follows:

- all lectures were held online using cloud video services according to the schedule;
- practical classes and laboratory work in each discipline were conducted according to the following scheme: every two weeks 1 class was held in the classrooms of KNEU (synchronous mode), 1 class – using cloud services of video communication according to the schedule (synchronous mode);
- the rest of the classes were conducted asynchronously through a distance course of the discipline, posted on the Moodle platform.

However, with the transition of Kyiv to the "orange" quarantine zone, blended learning switched to distance learning. What has changed? Contact classes from the audience were moved to a virtual environment, but with the preservation of the aspect of synchronicity of interaction (figure 3).

In addition, there was a question of ensuring the adequacy of students' knowledge during the mastering of the discipline "Organization of NoSQL databases" within the limited time allocated by the curriculum (5 credits), given the fact that the IT market has a significant variety of NoSQL DB, each type and model data in them – have significant technological features, as noted above. Based on previous research, in particular [39], teachers decided on the need for optional (if needed by students) expansion of the course through the use of MOOC platforms. This practice also falls within the framework of the recommendations of the Ministry of Education and Science of Ukraine on the recognition of non-formal learning outcomes.

To select online courses that are potentially relevant to the curriculum of the discipline "Organization of NoSQL databases", an analysis of existing MOOC platforms was conducted using the web resource MOOC-LIST [68], the results of which are presented in table 1, based on the basic circumstances in the course DB NoSQL defined:

- Document-Oriented – MongoDB;
- Graph Databases – Neo4j;
- Key/Value – Redis;
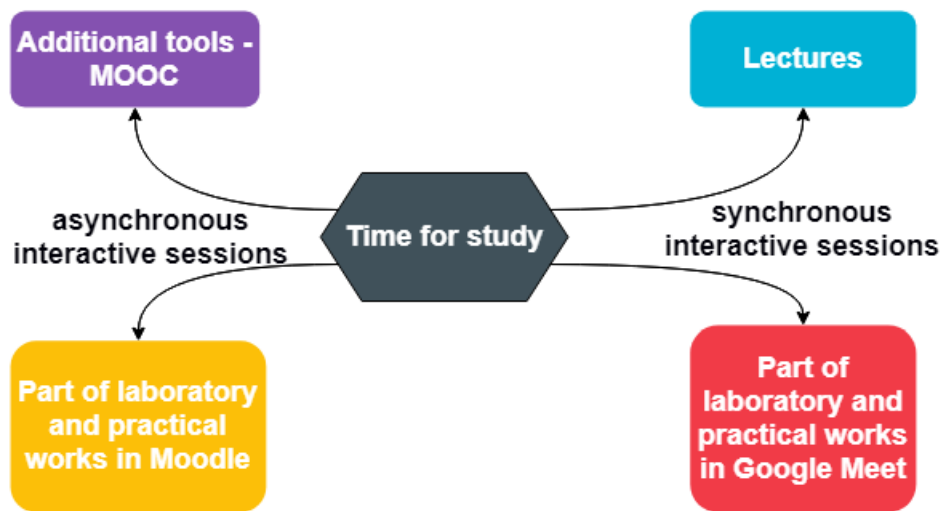- Tabular Column-oriented – Cassandra.

Figure 3. Time distribution between synchronous and asynchronous modes of operation within the distance learning mode.

The presented data show that the presented MOOCs contain courses on various aspects of NoSQL in a fairly wide range. In order to select the most appropriate objectives for the MOOC course, several criteria were established:

- no cost for the course;
- the possibility of obtaining a certificate free of charge for the results of mastering the course (according to the rules, the certificate is the basis for recognition of the results of non-formal learning);
- the MOOC must contain a course related to one or more basic DB NoSQL courses;
- language of instruction – English, because it is the most pragmatic option both in terms of students' understanding of the material and in terms of soft-skills development;
- training period – should not exceed 2 months (ideally – a few weeks).

Thus, the Udemy, LinkedIn Learning Courses, and edX platforms were rejected due to the provision of services and/or certification on a paid basis. But Coursera has opened access to online courses for students and teachers of KNEU under the program Coursera for Campus (Basic plan). Educational MOOCs from NoSQL vendors are essentially open and accessible and are well suited to the task of deepening knowledge and skills of working with NoSQL DB in students within the discipline "Organization of NoSQL databases". For example, MongoDB University offers a wide range of basic courses to study various aspects of MongoDB. Students, depending on the level of their motivation and pedagogical tasks are offered the following: M001: MongoDB Basics, M100: MongoDB for SQL Pros, M201: MongoDB Performance. For completing the current tasks of the online course, the student receives points, similar to the usual educational process in HEI (figure 4).

As a final control, MongoDB University offers to pass the Exam in the form of a test, which contains both theoretical questions and practical tasks to be performed in MongoDB and choose, based on the results, the correct version of the proposed. The overall grade for the course is the average between the scores of the current performance and the results of the Exam (figure 5).

Table 1. Comparative characteristics of individual MOOC platforms containing online courses with NoSQL.

Categories / MOOC	Udemy [69]	edX [70]	Coursera [71]	LinkedIn Learning Courses [72]	Redis University [73]	Nedo4j graphacademy [74]	MongoDB University [75]
Nomenclature DB	MongoDB, Neo4j, Apache Spark, Hadoop, Redis, Cassandra, HBase, IBM Cloudant	DynamoDB, MongoDB, IBM Cloudant	MongoDB, DynamoDB, Apache Spark, Neo4j, Hadoop, Redis, Cassandra	Cassandra, MongoDB, Redis, CouchDB, Riak et	Redis	Neo4j	MongoDB
Available courses NoSql:	12	8	35	160	7	11	13
beginners	8	2	11	29	1	3	4
intermediate	3	3	6	92	5	5	6
advanced users	1	3	12	39	1	3	3
Free of charge	–	almost all	+	1-month free trial	+	+	+
Certificate	included in the price	payment required	for free	included in the price	free certification exams	free certification exams	for free
Period of study	no time limit	4 months	from 2 hrs till 4 months	from 2 months	1 months	from 2 hrs till 2 days	2 months
Language	English, Spanish, Portuguese, Chinese	English, Chinese	English, Spanish, French, Russian, Portuguese, Chinese	English	English	English	English

Based on the overall score, if the student has mastered the course program and passed at least 65% of the course grade, MongoDB University provides a certificate – Proof of completion, which can be printed or shared on social networks such as Facebook or LinkedIn.
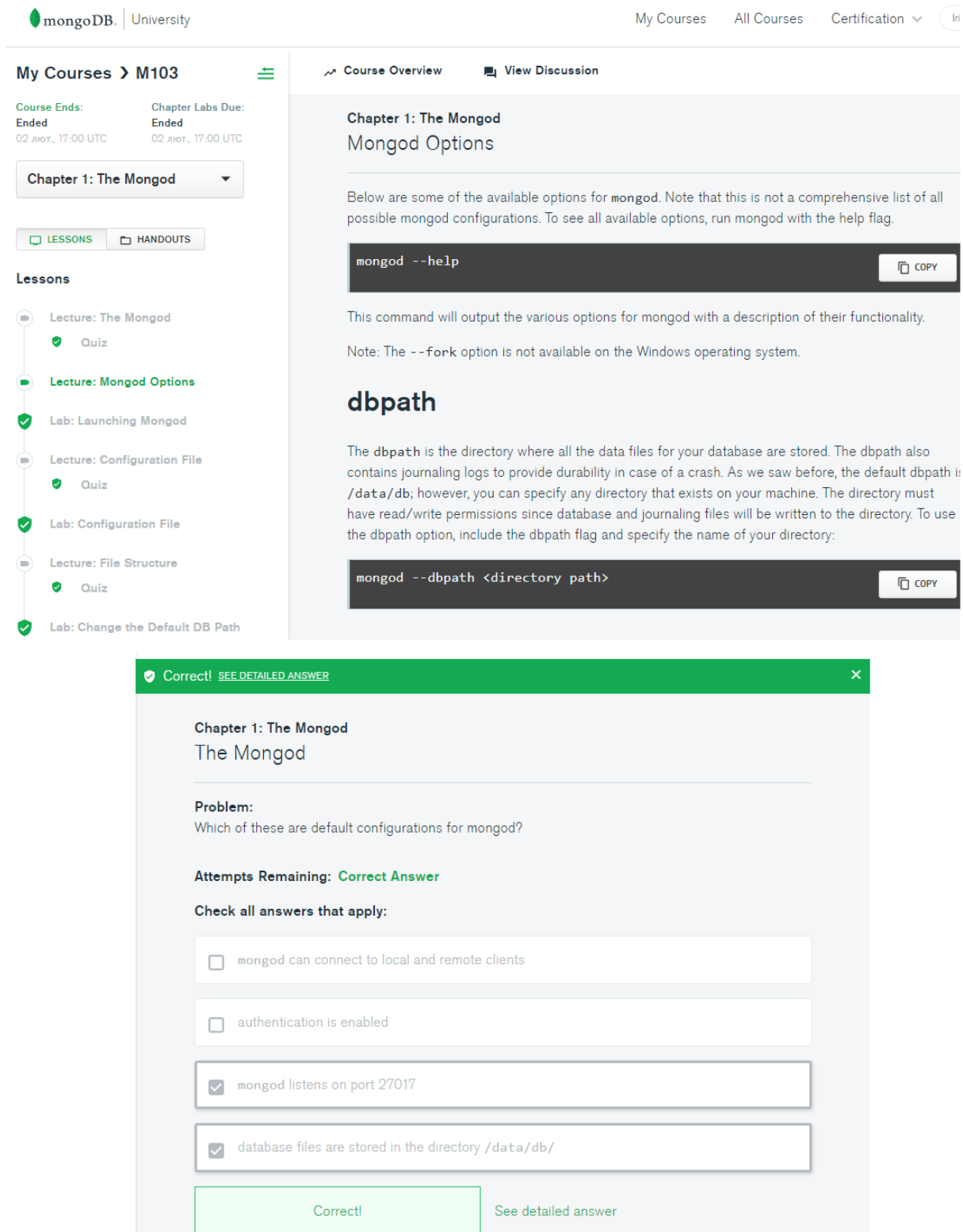
Figure 4. Examples of tasks in online courses at MongoDB University [75].

Figure 5. The results of the course M001: MongoDB Basics [75].

4. Results

To analyze the effectiveness of innovations in the transformation of the discipline "Organization of NoSQL databases", during November-December 2020, an anonymous survey was conducted among students of 3–6 courses (https://forms.gle/bWK9zaubqL4e64eR9). The distribution of respondents is presented in figure 6. The data obtained indicate several important results:

- by the time students studied the discipline "Organization of NoSQL databases", 55.9% of them had already encountered the concept of NoSQL (at work, during training, self-education, etc.);
- 26.5% of students, before studying the discipline "Organization of NoSQL databases" tried to search for online courses and study;
- 76.5% of respondents consider studying this course within the educational and professional program – useful and important, and 44.1% – necessary for a career in IT;
- 52.9% expressed a desire to take an additional (in-depth) course related to DB NoSQL (in particular, to study the processes of administration, integration, etc.);
- 85.3% stated that in this course it is important for them to gain knowledge of a practical nature (query language, syntax, creation, and filling of DB);
- 26.5% of students find it useful to take additional courses at MOOC Coursera, 36.2% – MOOC from vendors, in particular: MongoDB University, Nedo4j graphacademy, Redis University; others noted that they had enough practice material to provide the course (17.6%) and expected to gain more knowledge in the workplace (19.7%);
- 38.2% of students determined that they consider the use of MOOC as an additional learning tool useful for them (figure 7). But here it is worth paying attention to the fact that 44.1% of students note the overload of education, which should definitely be taken into account.

Therefore, the presented results give us reason to believe that the use of MOOCs as an additional learning tool for disciplines related to NoSQL DB in blended learning and distance learning is appropriate, which is also confirmed by the results of the survey. Obviously, the best way to learn the structures of the query language and the principles of operation of a particular NoSQL DB – practical work with them, designing a real DB and query processing. The current limitations of blended and distance learning don't allow for the training of the required skills within the training time exclusively, so it is important to use additional learning tools. At the same time, the problem of overload, which is caused by the increase in study time required to acquire additional knowledge, is also a task that the author's team still needs to deal with.

5. Conclusion

The new reality of the higher education system is blended learning and distance learning, in which part of the time allotted by the curriculum for mastering disciplines should be spent in
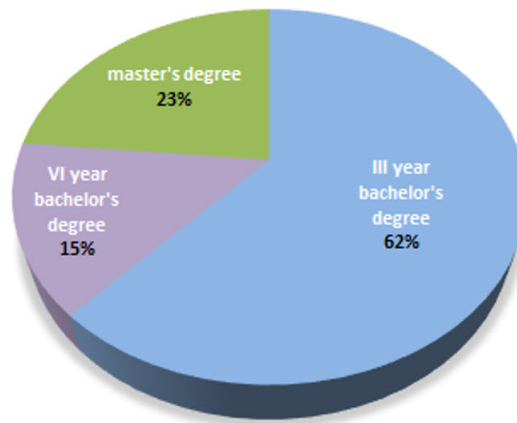
Figure 6. Structure of respondents who took part in the survey (total number – 64 people).
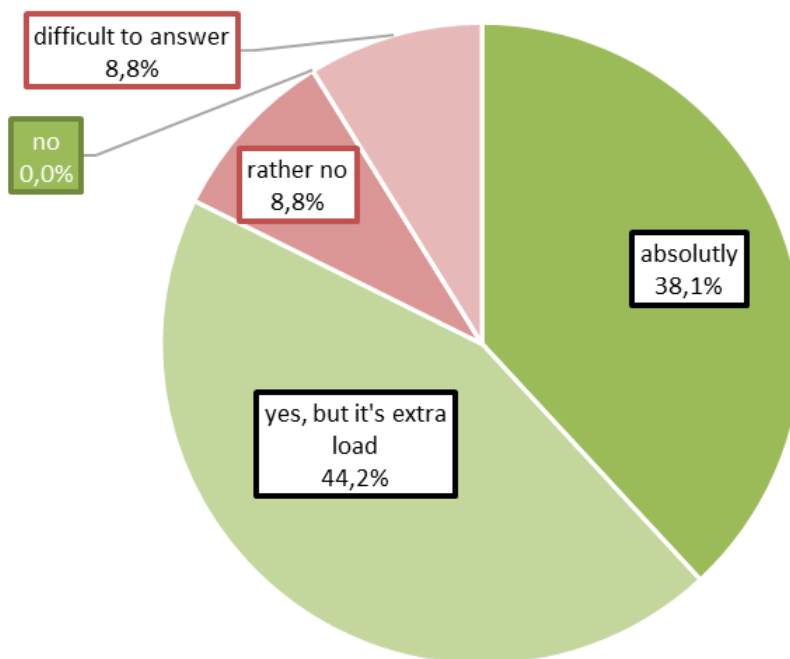

Figure 7. Respondents' level of satisfaction with the use of MOOC as an additional learning tool (total number – 64 people).

synchronous mode (i.e. in interactive interaction "teacher – student" either classroom or virtual), the other – asynchronous. Accordingly, there is a rapid development of software products and online tools e-Learning of various orientations (MOOC, LMS, online programming judge system, online coding platform, etc.). In addition, the organization of the educational process in distance or blended form requires consideration of the specifics of training higher education, taking into account specialties, specifics of educational programs, expected learning outcomes, and, last but not least, the demands of employers. In this context, it is important and relevant for graduates of different levels and specialties to master the skills of working with NoSQL DB and, accordingly, the inclusion in the curriculum of disciplines that shape them.

Analysis of the results of research by various authors has shown that the use of online tools for

blended learning is appropriate and justified. In particular, scientists argue that it is appropriate to use, for example, MOOC in training courses for students of various specialties, including engineering and computer specialties. However, the research also emphasizes that important prerequisites for the effective use of MOOC in the practice of HEIs and research institutions should be: 1) maintaining a balance between asynchronous and synchronous regimes of the educational process; 2) the use of MOOC in the educational process must be preceded by a justification for such a choice.

The authors of the publication consider the experience of using MOOC in the study of the discipline "Organization of NoSQL databases", taught in Kyiv National Economic University named after Vadym Hetman. It is shown how the change of teaching models has influenced the transformation of ways of presenting information by teachers to students, the inclusion in the educational process of additional online tools, including a number of MOOCs. Based on the results of a comparative analysis of distance learning platforms containing courses related to DB NoSQL, it was determined that Coursera, MongoDB University, Redis University, and Nedo4j graphacademy will be the most optimal for teaching this course. This experience has been useful in the context of updating the content and operational components of academic disciplines related to the design and study of databases for G.E. Pukhov Institute for Modeling in Energy Engineering of NAS of Ukraine, it is expected to spread to various institutions, including the National Aviation University, Interregional Academy of Personnel Management, National University of Civil Defence of Ukraine and State Institution "The Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine".

A survey of students who studied the discipline "Organization of NoSQL databases" in different years showed a high level of satisfaction with the possibility of acquiring professional competencies, including through the use of MOOC as an additional online learning tool. On the other hand, the survey data showed a high level of concern of students about the increase in the level of study load in the case of decisions on the use of MOOC as an additional online tool for developing skills in working with NoSQL DB. This issue is important, debatable, and therefore requires further study and search for possible solutions.

References

[1] Shokaliuk S, Bohunenko Y, Lovianova I and Shyshkina M 2020 *CEUR Workshop Proceedings* **2643** 548–562 ISSN 16130073
[2] Syvyi M, Mazbayev O, Varakuta O, Panteleeva N and Bondarenko O 2020 *CEUR Workshop Proceedings* **2731** 369–382 ISSN 16130073
[3] Bobyliev D Y and Vihrova E V 2021 *Journal of Physics: Conference Series* **1840** 012002 URL https://doi.org/10.1088/1742-6596/1840/1/012002
[4] Bondarenko O, Mantulenko S and Pikilnyak A 2018 *CEUR Workshop Proceedings* **2257** 182–191 ISSN 16130073
[5] Polhun K, Kramarenko T, Maloivan M and Tomilina A 2021 *Journal of Physics: Conference Series* **1840** 012053 URL https://doi.org/10.1088/1742-6596/1840/1/012053
[6] Modlo Y, Semerikov S, Nechypurenko P, Bondarevskyi S, Bondarevska O and Tolmachev S 2019 *CEUR Workshop Proceedings* **2433** 413–428 ISSN 16130073
[7] Kholoshyn I, Bondarenko O, Hanchuk O and Shmeltser E 2019 *CEUR Workshop Proceedings* **2433** 403–412 ISSN 16130073
[8] Tkachuk V, Yechkalo Y, Semerikov S, Kislova M and Khotskina V 2020 *CEUR Workshop Proceedings* **2732** 1217–1232 ISSN 16130073
[9] Semerikov S O, Striuk A M, Vakaliuk T A and Morozov A V 2021 *CEUR Workshop Proceedings* **2850** 1–15 URL http://ceur-ws.org/Vol-2850/paper0.pdf
[10] Haranin O and Moiseienko N 2018 *CEUR Workshop Proceedings* **2292** 143–150 ISSN 16130073
[11] solid IT gmbh 2021 DB-Engines Ranking URL https://db-engines.com/en/ranking
[12] solid IT gmbh 2021 DB-Engines Ranking - Trend Popularity URL https://db-engines.com/en/ranking_trend
[13] Mintii I, Shokaliuk S, Vakaliuk T, Mintii M and Soloviev V 2019 *CEUR Workshop Proceedings* **2433** 529–540 ISSN 16130073

[14] Werner A and Bach M 2018 *Man-Machine Interactions 5* ed Gruca A, Czachórski T, Harezlak K, Kozielski S and Piotrowska A (Cham: Springer International Publishing) pp 581–592 ISBN 978-3-319-67792-7

[15] Sytnyk N and Zinovieva I 2019 *Proc. of the 2th National Scientific and Methodological Conf. "Digital Economy"* (Kyiv National Economic University named after Vadym Hetman) pp 150–153

[16] Korotun O, Vakaliuk T and Soloviev V 2020 *CEUR Workshop Proceedings* **2643** 281–292 ISSN 16130073

[17] Korotun O, Vakaliuk T and Oleshko V 2019 *CEUR Workshop Proceedings* **2546** 182–197

[18] Semerikov S, Striuk A, Striuk L, Striuk M and Shalatska H 2020 *E3S Web of Conferences* **166** 10036

[19] Kiv A, Semerikov S, Soloviev V and Striuk A 2019 *CEUR Workshop Proceedings* **2546** 1–20

[20] Iatsyshyn A, Iatsyshyn A, Kovach V, Zinovieva I, Artemchuk V, Popov O, Cholyshkina O, Radchenko O, Radchenko O and Turevych A 2020 *CEUR Workshop Proceedings* **2732** 893–908

[21] Iatsyshyn A, Iatsyshyn A, Artemchuk V, Kameneva I, Kovach V and Popov O 2020 *E3S Web of Conferences* **166** 01001

[22] Iatsyshyn A, Kovach V, Lyubchak V, Zuban Y, Piven A, Sokolyuk O, Iatsyshyn A, Popov O, Artemchuk V and Shyshkina M 2020 *CEUR Workshop Proceedings* **2643** 134–160

[23] Gurieiev V, Kutsan Y, Iatsyshyn A, Iatsyshyn A, Kovach V, Lysenko E, Artemchuk V and Popov O 2020 *CEUR Workshop Proceedings* **2732** 693–708

[24] Bakki A, Oubahssi L, George S and Cherkaoui C 2020 *Technology, Knowledge and Learning* **25** 899–927 ISSN 2211-1670 URL https://doi.org/10.1007/s10758-020-09444-8

[25] Tokarieva A, Volkova N, Harkusha I and Soloviev V 2019 *CEUR Workshop Proceedings* **2433** 74–89 ISSN 16130073

[26] Moiseienko M, Moiseienko N, Kohut I and Kiv A 2020 *CEUR Workshop Proceedings* **2643** 60–70 ISSN 16130073

[27] Kuzminska O, Mazorchuk M, Morze N and Kobylin O 2020 *Information and Communication Technologies in Education, Research, and Industrial Applications* ed Ermolayev V, Mallet F, Yakovyna V, Mayr H C and Spivakovsky A (Cham: Springer International Publishing) pp 210–230 ISBN 978-3-030-39459-2

[28] Llerena-Izquierdo J and Valverde-Macias A 2021 *Systems and Information Sciences* ed Botto-Tobar M, Zamora W, Larrea Plúa J, Bazurto Roldan J and Santamaría Philco A (Cham: Springer International Publishing) pp 391–401 ISBN 978-3-030-59194-6

[29] Myshchyshen A 2011 *Visnyk pislyadyplomnoyi osvity* **5** 96–105

[30] Vlasenko K, Chumak O, Achkan V, Lovianova I and Kondratyeva O 2020 *Universal Journal of Educational Research* **8** 3527–3535 ISSN 23323205

[31] Mintii I 2020 *CEUR Workshop Proceedings* **2643** 293–305 ISSN 16130073

[32] Abdula A, Baluta H, Kozachenko N and Kassim D 2020 *CEUR Workshop Proceedings* **2643** 306–320 ISSN 16130073

[33] Tkachuk V, Yechkalo Y, Semerikov S, Kislova M and Hladyr Y 2021 *Information and Communication Technologies in Education, Research, and Industrial Applications* ed Bollin A, Ermolayev V, Mayr H C, Nikitchenko M, Spivakovsky A, Tkachuk M, Yakovyna V and Zholtkevych G (Cham: Springer International Publishing) pp 46–67 ISBN 978-3-030-77592-6

[34] Tayebinik M and Puteh M 2012 *International Magazine on Advances in Computer Science and Telecommunications* **3** 103–110

[35] Chango W, Cerezo R and Romero C 2021 *Computers & Electrical Engineering* **89** 106908 ISSN 0045-7906

[36] Greenhow C and Galvin S 2020 *Information and Learning Science* **12** 513–524

[37] Perera I 2010 *US-China Education Review* **7** 76–82

[38] Callo E C and Yazon A D 2020 *Universal Journal of Educational Research* **8** 3509–3518

[39] Zinovieva I S, Artemchuk V O, Iatsyshyn A V, Popov O O, Kovach V O, Iatsyshyn A V, Romanenko Y O and Radchenko O V 2021 *Journal of Physics: Conference Series* **1840** 012029 URL https://doi.org/10.1088/1742-6596/1840/1/012029

[40] Pinto J D, Quintana C and Quintana R M 2020 *Computing in Science Engineering* **22** 97–102

[41] Chen B, Fan Y, Zhang G, Liu M and Wang Q 2020 *PLoS ONE* **15** e0235170

[42] Formanek M, Buxner S, Impey C and Wenger M 2019 *Phys. Rev. Phys. Educ. Res.* **15**(2) 020140 URL https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.15.020140

[43] Bendezu-Quispe G, Quijano-Escate R, Hernndez-Vsquez A, Inga-Berrospi F and Condor D F 2020 *Revista Latino-Americana de Enfermagem* **28** ISSN 0104-1169

[44] Rizvi S, Rienties B, Rogaten J and Kizilcec R F 2020 *Journal of Computing in Higher Education* **32** 162–181 ISSN 1867-1233 URL https://doi.org/10.1007/s12528-019-09231-0

[45] Strutynska O and Umryk M 2016 *Handbook on the Physics and Chemistry of Rare Earths* ed Smyrnova-Trybulska E (Katowice-Cieszyn: Studio-Noa) pp 297–320

[46] Kukharenko V 2013 *2013 IEEE 7th International Conference on Intelligent Data Acquisition and Advanced Computing Systems (IDAACS)* vol 02 pp 760–763

[47] Kukharenko V 2013 *CEUR Workshop Proceedings* **1000** 273–280

[48] Idrissi Jouicha A, Berrada K, Bendaoud R, Machwate S, Miraoui A and Burgos D 2020 *IEEE Access* **8** 17477–17488

[49] Cong W, Yu H and Liu J 2021 *Application of Intelligent Systems in Multi-modal Information Analytics* ed Sugumaran V, Xu Z and Zhou H (Cham: Springer International Publishing) pp 573–578 ISBN 978-3-030-51556-0

[50] Dai H M, Teo T and Rappa N A 2020 *Computers in Human Behavior* **112** 106455 ISSN 0747-5632

[51] Mellati M and Khademi M 2020 *Interactive Learning Environments* **28** 1022–1035 URL `https://doi.org/10.1080/10494820.2018.1553188`

[52] Nakayama M, Sciarrone F, Uto M and Temperini M 2021 *Methodologies and Intelligent Systems for Technology Enhanced Learning, 10th International Conference. Workshops* ed Kubincová Z, Lancia L, Popescu E, Nakayama M, Scarano V and Gil A B (Cham: Springer International Publishing) pp 25–35 ISBN 978-3-030-52287-2

[53] Pozn-Lpez I, Kalinic Z, Higueras-Castillo E and Libana-Cabanillas F 2020 *Interactive Learning Environments* **28** 1003–1021 URL `https://doi.org/10.1080/10494820.2019.1636074`

[54] Seidametova Z 2018 *CEUR Workshop Proceedings* **2104** 462–471 ISSN 16130073

[55] Panchenko L and Muzyka I 2020 *CEUR Workshop Proceedings* **2547** 168–180 ISSN 16130073

[56] Korotun O V 2018 *Use a cloud oriented environment to training future teachers of Information Science to master database* Ph.D. thesis Institute of Information Technologies and Learning Tools of NAES of Ukraine Kyiv

[57] Globa L, Ternova M, Novogrudska R and Shtogrina O 2018 *Creation and processing of databases* (Kyiv: NTU Ukrayiny "KPI")

[58] Sharov S and Osadchyi V 2014 *Databases and information systems* (Melitopol: Vyd-vo MDPU im. B. Khmelnytskoho)

[59] Kruglyk V and Osadchyi V 2019 *Integration of Education* **23** 587–606

[60] Markova O, Semerikov S, Striuk A, Shalatska H, Nechypurenko P and Tron V 2019 *CEUR Workshop Proceedings* **2433** 499–515

[61] Glazunova O, Voloshyna T, Korolchuk V and Parhomenko O 2019 *E3S Web of Conferences* **166** 10014

[62] Lara J, Sojo A D, Aljawarneh S, Schumaker R and Al-Shargabi B 2020 *IEEE Access* **8** 22988–23001

[63] Miller T, MacLaren K and Xu H 2020 *Canadian Journal of Learning and Technology* **46** 1–27 URL `https://www.cjlt.ca/index.php/cjlt/article/view/27894/20482`

[64] Smart K and Cappel J 2006 *Journal of Information Technology Education* **5** 201–219 URL `http://www.jite.org/documents/Vol5/v5p201-219Smart54.pdf`

[65] Lourenço J R, Cabral B, Carreiro P, Vieira M and Bernardino J 2015 *Journal of Big Data* **2** 18 ISSN 2196-1115 URL `https://doi.org/10.1186/s40537-015-0025-0`

[66] Abdullah A and Zhuge Q 2015 *Research Journal of Applied Sciences, Engineering and Technology* **11** 434–439

[67] 2020 Disciplines of the bachelor's degree for computer science in kyiv national economic university named after vadym hetman URL `https://fisit.kneu.edu.ua/ua/depts9/k_informacijnyh_system_v_ekonomici/fisit_ise_op/`

[68] MOOC List 2021 NoSQL Free Online Courses and MOOCs URL `https://www.mooc-list.com/tags/nosql`

[69] Udemy 2021 Online Courses - Learn Anything, On Your Schedule URL `https://www.udemy.com/`

[70] edX 2021 Free Online Courses by Harvard, MIT, & more URL `https://www.edx.org/`

[71] Coursera 2021 Build Skills with Online Courses from Top Institutions URL `https://www.coursera.org/`

[72] LinkedIn 2021 LinkedIn Learning with Lynda: Online Training Courses for Creative, Technology, Business Skills URL `https://www.linkedin.com/learning/`

[73] Redis Labs 2021 Learn Redis with Free Online Courses URL `https://university.redislabs.com/`

[74] Nedo4j 2021 GraphAcademy - Neo4j Graph Database Platform URL `https://neo4j.com/graphacademy/`

[75] MongoDB 2021 Free MongoDB Official Courses — MongoDB University URL `https://university.mongodb.com/`