CLOUD TECHNOLOGIES IN MANAGEMENT OF PEDAGOGICAL EDUCATION INSTITUTIONS

[a]VERONICA ODARCHENKO, [b]OLENA AKIMOVA, [c]OKSANA KUZNETSOVA, [d]VALENTYNA LYTVYN, [e]SVITLANA KARPLIUK

[a,b,c,d]*Department of Pedagogy, Psychology, Primary Education and Educational Management, Municipal Establishment Kharkiv Humanitarian-Pedagogical Academy of the Kharkiv Regional Council, Kharkiv, Ukraine,*
[e]*Department of Computer Science and Information Technology, Zhytomyr Ivan Franko State University, Zhytomyr, Ukraine*
email: [a]anika.odarchenko@gmail.com,
[b]*elenkaakimova@ukr.net, [c]OksanaKharkov08@gmail.com,*
[d]*mrs.valentynka@gmail.com, [e]aleksa@zu.edu.ua*

Abstract: This article highlights the features of cloud technologies in the management of pedagogical higher education institutions. The aim of the study is to systematize relevant information on the use of cloud technologies in the management of pedagogical higher education institutions. According to the results of the study, we can conclude that before the pandemic, the situation in the field of cloud computing was quite different. Only some of the world's best universities were implementing cloud technology in their management processes. Today, almost every higher education institution in the world fully or partially implements cloud technology to provide distance education.

Keywords: Cloud Technology, Pedagogy, Higher Education Institution, Distance Education.

1 Introduction

Information technologies and computerization in all education spheres have been one of the main trends in the development of society for many years. Although new information technologies are introduced into the educational process, higher educational institutions are equipped with computers and permanent access to the Internet, which teachers and students openly use.

These processes have formed a new scientific and technical foundation for developing and functioning virtual tools in education. Creating a virtual educational environment is one of the essential methodological and pedagogical tasks for the effective organization of the educational process. It consists of the development of university infrastructure, namely the information environment, which implies the introduction of new information services. New information technologies serve as tools used to solve individual pedagogical tasks and provide new opportunities for the learning process.

The expansion of information technology capabilities requires the creation of new information infrastructure to meet the needs of the learning process, which is undoubtedly a significant burden on the university. Different approaches and methods form the basis of information systems that support the activities of the virtual space of an educational institution. One of these tools is cloud computing, which forms a promising area that offers enormous advantages in data management. Cloud computing technology is understood as a model that allows combining information and technological resources of different hardware into one and providing user access through a local or a global Internet network (Fofarti, 2011; Emelyanova, 2014).

2 Literature review

The issue of cloud technologies in education is widely researched in the scientific literature. In general, studies can be classified into general studies that define the structure and models of such technologies. Also, some studies determine the usefulness of cloud technology for individual universities or countries. Much of the research is quite specific and focuses on assessing the effectiveness of cloud services for the teaching of specialists in certain professions.

Pardeshi (2014) Islam et al. (2017) looked at the use of cloud service in the interactions of different universities. The author noted the main benefits of using technology and identified leading models: IaaS, PaaS, and SaaS, and their benefits in the

educational process. The author also defined the classification of models in terms of their availability: private, collaborative, public, hybrid. The study focuses on the implementation of these models in the educational process.

Hasibuan & Selviandro (2013), Viswanath et al. (2012) identified the importance of cloud technologies for distance learning. They showed the benefits of cloud services for higher education institutions and the features of the architecture. Almajalid, R. (2017) surveyed the use of cloud technology by educational institutions. As a result, the main advantages of the transition to cloud technology were identified: data protection, information quality, integration capabilities, and the like. The research was carried out on the example of The University of California (UC), The University of Westminster (UOW), Eastern Michigan University (EMU). According to the study results, it was determined that the use of cloud technology could save money, increase the number of studies and improve the interaction between the participants in the educational process. Zhao, K. (2017) examined the specifics of using a Google cloud service in the educational process. The main emphasis was placed on implementing this environment in the educational process, which aims to build effective interaction between students. And in turn, Kasiolas, V. (2017) conducted a study on the effectiveness of cloud services for teachers.

The research on the implementation of cloud models in the educational process of dentists is also interesting. This study was conducted by Zorina, Berkutova, Petruhina (2016); it summarizes the information on models and types of cloud environments and studies the practical use of cloud services and their importance in training future specialists. Averina, I. (2014) carried out similar research for the training of economists and accountants in Belarus. However, as for studies in pedagogical higher education institutions, they are sporadic and insufficiently covered. At the same time, most of these studies were carried out before introducing mass distance learning associated with the pandemic. Therefore, modern studies of cloud technologies are not enough to assess their importance and relevance for educational institutions. This fact forms the significance of the research and allows us to formulate the aim of the study: to systematize current information on the use of cloud technologies in the management of pedagogical higher education institutions.

3 Materials and research methods

This research includes general scientific methods: analysis and synthesis. To build the study, the information was systematized with its synthesis into the following components: the importance of cloud services in the educational process, the main advantages of using such technologies, a practical analysis of technology using by universities on the basis of survey data. The paper also makes a critical approach to defining the essence of cloud service and its structure. Based on the literature study results, a list of the most used cloud technologies by higher education institutions was collected. The main problems in using technology in higher education institutions are highlighted. Based on this information, a proposal for the functional use of cloud technology for pedagogical universities was made, the problems of technology implementation and ways to solve them were identified.

4 Results

In the global community, many universities are allocating more and more resources to improve their positions in international rankings. For example, Lone Star College System (Texas, USA) today ranks second among the most innovative universities, and it uses cloud technology in its educational process. Purdue University (West Lafayette, Indiana, USA) actively uses social media in the educational process, in particular Twitter, Facebook. Massachusetts Institute of Technology (Cambridge, Massachusetts, USA) has assembled one of the largest artificial

intelligence labs; 77 MIT scientists are Nobel laureates (Stefanovich, 2018). The truth is simple: many institutions need to enter a new stage of their development to be among the most prestigious universities. One of the main tasks is to solve the problem is to implement electronic services and cloud computing technology. As the result the students will get teaching materials, the teachers – control of the learning process and preparation for lectures, the manager of the university – the levers of management, the accounting department – accounting services. Each of these users has the need to obtain the necessary information, and at the same time, it does not matter how it is implemented, who provides these services, and where they are physically located.

Foreign scientists have also paid attention to the use of cloud technology in the educational process. So, Italian scientist Fini A. (2009) notes that the main promising direction in the development of information technology based on cloud computing is the possibility of practical use by students of convenient network tools in learning and obtaining new knowledge (Fini, 2009).

The use of cloud technology has many advantages among other educational programs and services (see Fig.1).
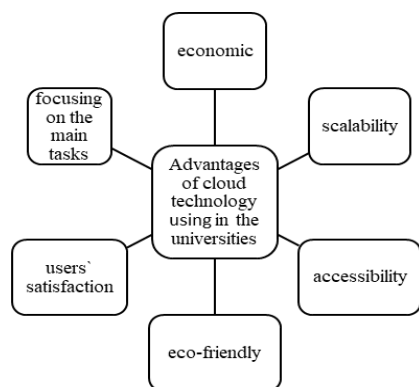

Figure 1 – The main advantages of using cloud technology in the management of pedagogical higher education institutions

Economic advantages. The use of cloud technology does not require capital expenditure on the creation and maintenance of data centers, the purchase of server and network equipment to create your IT infrastructure. The purchase and installation of expensive software and regular updates of platforms and systems are also unnecessary. The cloud solution provider bears all these costs. As a result, the workload of technical staff is reduced, allowing the same research staff to be involved in other projects useful to the institution.

Flexible scalability. Due to such characteristics of cloud services as elasticity, the institution has an opportunity to gradually increase the volume of used services without significant up-front investments. During peak usage periods (for instance, during sessions), there is no need to plan additional information capacities because cloud services can scale automatically and almost infinitely.

High availability. According to Internet service providers, cloud services are available 99.9% all the time. This is very convenient for all participants in the educational process since they can implement learning opportunities virtually at any time and not depend on the institution's local information and educational resources. As a result, this leads to tremendous time savings. In addition, constant accessibility removes barriers to distance education, for example, in remote regions where the learning process can be affected by time differences. The high availability of educational resources has a favorable effect on the rating of the educational institution.

Reducing the impact on the environment. Many countries have embraced energy-efficient ("green") technologies that are less damaging to the environment than traditional technologies. Following the "green" concept, data centers must use energy-efficient technologies in their design and operation. As practice shows, it is more advantageous to use cloud services that use "green" technologies to reduce the environmental impact than to implement such technologies in the local IT infrastructure. For example, Google claims an 80-fold increase in energy efficiency when using its cloud technologies (Google Apps for education).

Meeting the needs of end-users. For end-users, cloud technology provides even more benefits. It is very convenient when data is available from any place with the Internet and from any device (personal computer, smartphone, tablet, etc.). Users don't have to worry about backing up their information because it is safely stored in the cloud. The cloud infrastructure guarantees data security. Talking about a standard office package delivered to educational institutions free of charge and can be used for a wide range of tasks, users will not need to spend money to buy software and time to install and update it on their computers. The only software that will require an upgrade is the web browser.

Concentration on key tasks. In any field of education, the main task of educational institutions is to focus on education and research. Using cloud technology reduces the cost of deploying and maintaining applications used in work, freeing up human resources that can be used in the educational process.
According to a study regularly conducted on cloud services, higher education institutions use cloud technologies for 25% as computing power, 29% to organize correspondence within the university, and 31% for information storage (see Fig.2).
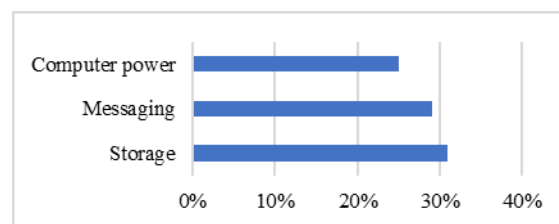

Figure 2 – Goals of using cloud technology in higher education institutions
Source: CDW's 2013 State of the Cloud report

In this case, universities use and apply different technologies that belong to the cloud. In order to study the issue on a scientific level, first, we need to understand what cloud technology is. There are many different interpretations of cloud technology; in particular, if we talk in simplified terms, it is a centralized, remote data center in which computer resources and capacities are provided to the end-user as an Internet service (Kolesov, 2014).

According to the US National Institute of Standards and Technology NIST, which is likely to be adopted at the JTC1 ISO/IEC level as well (Carlson, 2011): "Cloud technology is a model for providing ubiquitous and convenient network access as needed to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be quickly provisioned and released with minimal management effort or interaction with the service provider" (NIST).

In order to understand the specifics of using cloud technologies, it is necessary to study their structure. In general, there are three main types of cloud models:

▪ IaaS (Infrastructure as a Service) is the provision of computer infrastructure in the form of virtualization as a service.
▪ PaaS (Platform as a Service) provides an integrated platform for developing, testing, deploying, and maintaining web

applications as a service. The architecture is designed at Microsoft and consists of several components.

▪ SaaS (Software as a service) is a business model for selling software. Using this software, the developer, aka a vendor, develop a web application and manages it independently, providing customers with access to the software over the Internet (Fogarty, 2011).

Let us consider these cloud models to identify the possibility of applying them in the university's educational process. The IaaS model consists of an operating system and an application; its service provides the consumer with network processing and storage systems and many other fundamental computing resources to host and use various software. Thus, the consumer controls the core components of the cloud but has no control over the operating system (Ratushnaya & Kovalchuk, 2014).

The PaaS model provides the ability to rent a platform for developing and hosting applications. This model is a service provided over the Internet and consists of software, an operating system, and a database. Typically, this platform focuses on specific programming languages such as Java or Python and primarily uses software developers.

The SaaS model allows the consumer to use off-the-shelf application software, as the provider maintains the service in a cloud infrastructure. Applications are available using various devices or through thin client interfaces, such as a web browser or software interfaces, which move a large amount of information processing tasks to the server. The user does not directly manage the underlying cloud infrastructure, networks, and servers in this model. Today, many SaaS offerings range from specialized industry-specific projects to consumer applications such as email (Rudenko, 2020). The research showed that SaaS technologies, i.e., software for organizing education, are used the most (see Fig. 3).
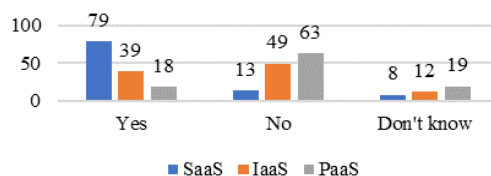

Figure 3– Most used cloud technologies at universities, %
Source: eCampus News, 2015

But it should be noted that the COVID-19 crisis has completely reshaped the cloud technology market. As a result, in 2021, the top priority for higher education institutions is the transition to modern cloud technology (see Fig. 4).
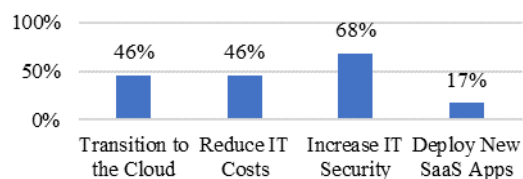

Figure 4 – Top priorities of higher education institutions for 2021
Source: OKTA, 2021

At the same time, universities in different countries are trying to choose one technological solution in order to organize at least communication processes. However, today there is a problem in communication between the student and the teacher and in providing quality education. Therefore, it is necessary to transfer the entire educational process to cloud platforms to help students easily find the essential information and use it without restrictions (see Table 1).

Table 1. The most popular cloud platforms for education

№	Name	Field of use
1	Moodle	Developed by Australian programmers, and is one of the most popular in the world. The platform has about 20 million users and three million courses. It is a boxed solution; it can be freely downloaded from the Internet. Payment is made for additional services and space for storing files (Sclater, 2010).
2	IBM Lotus (Workplace Collaborative Learning, WCL).	A development by IBM. Universal, flexible, and easily scalable platform for organization of distance electronic education, management of educational resources and materials. It can be used for professional development in big companies as well as in educational institutions.
3	Shareknowledge	Developed by Competentum. It is a free out-of-the-box solution. The platform's main advantage is the ability to independently organize the whole cycle of distance learning, from course development, preparation, delivery to class management and students' knowledge control level. Text and multimedia files are used in training. Teachers can give students tasks with a time limit, starting and finishing tasks, etc. Assessment of trainees' knowledge level is realized with the help of electronic tests.
4	WebTutor	The program is developed by the Russian software manufacturer WebSoft. It has a modular approach, allowing to organize adjusted systems on the basis of a set of program modules, which functions depend on the customers' purposes.
5	G Suite for Education	G Suite for Education provides a set of services from Google but is available in the *.edu domain. Gmail, Drive cloud storage, services for creating spreadsheets, documents, presentations, and websites (Sheets, Docs, Slides and Sites). Since the product is focused on covering an entire institution, a corporate account is supposed to be registered for the person in charge. User accounts with different access rights are created within the corporate account. (Leonov, 2012).
6	Microsoft Office 365	Microsoft Office 365 for Education allows educational institutions to take advantage of all the features of cloud services, helping to save time and money and improve student and employee productivity.
7	Windows Azure in education	Offer educators the opportunity to incorporate one of the most innovative and fastest-growing technologies into their teaching, both in theory and in practice (Safonov, 2013).
8	Learning Management Systems	Its use is reasonable for those educational institutions which cannot afford the purchase and maintenance of software and expensive equipment.

The most common cloud-based service systems used in education are Live@edu from Microsoft and Google Apps Education Edition from Google (Aleksanyan, 2014). Google office suites, Google Apps for Educations, Office Online, Office 365, and Zoho Office are examples of service applications and can provide collaboration capabilities. Google packages for education include a free and ad-free suite of tools that enable teachers and students to interact, teach and learn more successfully and effectively. All the listed features of cloud storage services allow professors to store all the methodical documentation in the "cloud" and organize joint access to cloud storage for students and other professors, quickly monitor the student's progress and results of the educational process. This is one of the promising opportunities to expand the available

toolkit of modern teachers and their management regardless of the geographical distance. This is a more advantageous proposition than creating a virtual one among universities, which

have long been ineffective in a pandemic environment. Table 2 describes the problems that arise when supporting software and equipment with and without cloud technology.

Table 2: Comparative characteristics of cloud technology in the management of higher educational institutions

Challenges of using cloud technology	Opportunities to use cloud technology
High purchase and maintenance costs of hardware for teachers	Possibility to use data from any computer connected to the Internet
The need to maintain the equipment, which leads to an increase in the staff of IT-specialists at pedagogical university	Possibility to process data from various devices, including cell phones, which is especially important for students
High labor costs to maintain rather than develop educational infrastructure	Possibility to process data from any operating systems and browsers
The difficulty of organizing corporate mobility of licensed software	No need to copy data to move it from one workplace to another
Non-intrusive access to the database of persons who can disrupt the educational process	Possibility of quick recovery of the software (if a licensed version is available)
Problems of integration and interaction of information of different cloud technologies	Easy organization of laboratory and practical classes on pedagogy with the connection to the pedagogical process of any school

Pedagogical universities need to train such specialists who will be able to teach in a distance education environment. Based on the above, it is possible to highlight the main functions of cloud platforms for higher education pedagogical institutions, which are shown in Fig. 5.
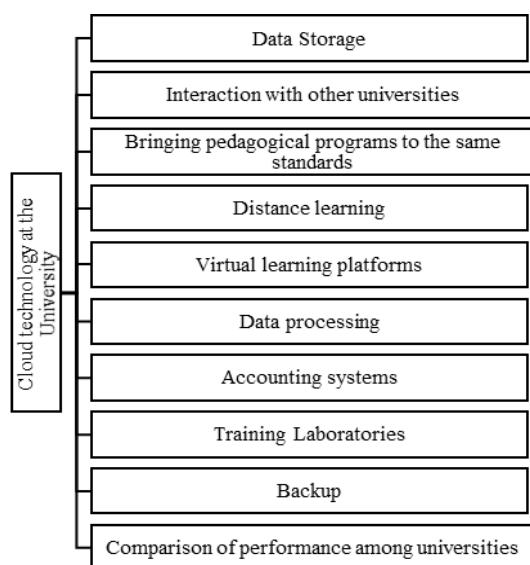

Figure 5 – Functionality of cloud technology in pedagogical universities

To this end, it is necessary to study and use different cloud technologies in education so that future specialists will be ready to solve such technical tasks in practice. In this case, it would be advisable to use popular technical solutions, which are guaranteed to have good prospects and develop over time. Furthermore, it is necessary to make a conscious choice of cloud products to consider online platforms that could unite the scientific process in all connected educational institutions. In this way, teachers could actively interact with colleagues from other institutions, share experiences, and solve problems together.

5 Discussion

Nowadays, when different educational institutions use different cloud technologies in the educational process, it is important to consider the issue of shell interoperability. Practice shows that educational institutions often need to organize joint conferences, virtual meetings and efficiently exchange data. The main problems of cloud technology interoperability are:

▪ different approaches to storing and configuring operating systems and applications;
▪ the use of different security standards and management interfaces;

▪ the inability to quickly integrate into a pedagogical environment (Fojtik, 2018).

Standards describe certain approaches and elements necessary for the infrastructure of universities and various business structures that face the challenge of creating universal standards of management and the possibility of interoperability of cloud platforms. A profile implies an agreed set of standards that must be compatible and updated as new standards are added. The Cloud Computing Profile should be based on documents such as the National Institute of Standards and The IEEE Standards Association (Aleksanyan, 2014).

Based on the above, the following conclusion can be made:

▪ higher education institutions have actively started to develop and find more and more applications for cloud computing, with the applied aspects significantly overtaking the fundamental aspects, so it is necessary to start studying this direction in the teaching programs to prepare qualified specialists who are ready for distance education;
▪ cloud computing represents, in general, the interconnection of different networks, servers, and workstations with different systems, for which the problem of interaction of heterogeneous information systems is most relevant. In the context of distance education, it would be right to use common cloud platforms to enhance students' education, which can compensate for the lack of information with available information of other universities.

The problem of interoperability, the possibility of interaction, joint work according to the experience of application in the world practice should be solved on the basis of open systems technology and the use of unified standards of information technology.

Many organizations around the world are addressing the problem of interoperability, interoperability, and collaboration for cloud computing, but the work is patchwork. Since institutions of higher education choose all cloud services on a competitive basis, there is no simple solution to the problem at the moment. On the contrary, with the development of new technologies, the issue only worsens, as more convenient and affordable services will constantly appear on the market, used by different higher education institutions looking for the best technological educational solutions. To improve the educational process, educational institutions in a city, region, or country can choose common platforms to work with, which will help educate students more efficiently and allow the efficient use of financial and human resources.

6 Conclusion

The issue of using cloud technology is quite studied in the theoretical aspect. When cloud technology emerged, the best universities in the world understood that it would allow a more effective interaction between administration and teachers,

between teachers and students, and between students. However, in the market, commercial companies present different technologies, and each of them has weaknesses and problems in use. Thus, to date, universities are looking for the best proposals that could provide the organization of the educational process and resource management (information, labor, financial) within the institution. Today, the transition to cloud technology is a must for every educational institution that provides distance learning. In light of the COVID-19 pandemic, all higher education institutions need to move to the cloud, but pedagogical institutions especially. Students of pedagogical universities should be ready to teach students and schoolchildren using cloud technologies, and therefore the implementation of such technologies in the educational process should be present today. At the same time, students should be able to use different platforms and configure their work as needed. At the same time, much higher education institutions have faced problems with the lack of online information for learning. Therefore the everyday use of common platforms could solve this issue. For example, instead of searching all over the Internet for necessary lectures, students could use one platform for universities of a particular specialty and find all the information they need. But the introduction of such platforms comes from the initiative of universities, which should unite and form more effective platforms for education, which is possible to do in the context of cloud educational platforms.

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