The effective use of telecommunication cloud services for the training of future computer science teachers

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ABSTRACT: This study has been focused on different approaches to the use of cloud technologies and their services in the training of future computer science teachers at the Batchelor level. This topic is particularly relevant in view of the current transition to distance forms of education, which necessitates the implementation of this type of training. The purpose of the study was to determine the main approaches in the training of future teachers using cloud technologies and services, and to test the effectiveness of their application. The research methods employed in the study included information resource analysis virtualisation and modelling. The study has been concerned with the *cloud* principle, which predetermined the selection of content, methods, forms and means for the optimal approach to the training of future computer science teachers. The selected approaches have been implemented and proven effective. The findings can be introduced into the practice of training teachers in other areas, as well as for postgraduate education.

INTRODUCTION

The modern information society has gone beyond the framework of information processes and gradually, with the development of information and communication technologies (ICT), has grown into a digital society. In these circumstances, collection, storage, processing and transmission of digital information takes place using ICT that can effectively, reliably and quickly implement these processes [1]. The digital society is faced with several problems, one of which is storing large digital data sets for the purpose of subsequent processing or transmission. Transition from paperless technologies to information technologies, then to digital ones, has both positive and negative aspects [2].

One of the positive aspects is undoubtedly the rejection of the *paper* version of documents and the need to print them, faster search for relevant information and its timely updating, saving on consumables (cartridge, paper), etc. At this stage of the transition to a digital society it is apparent that some people are not appropriately skilled, and thus unable to use digital technologies. Hence, the problem of information inequality has emerged, as well as problems with communication services, with the availability of modern telecommunications, mobile technical means among the population [3]. These problems are especially acute for the world community during the pandemic. Kazakhstan, similarly to other countries, was forced to act promptly and take appropriate measures for the mobile transition to remote work and distance learning.

Cloud-based education has solved a number of issues regarding the storage of educational activities and their results, and it has facilitated easy access to them. In view of this, it is necessary to teach future computer science teachers the principles of cloud technologies and their use in solving pedagogical problems. For this study, it was necessary to determine the goal, objectives and the content of teaching cloud technologies for computer science teachers at the Batchelor level. The purpose of the study was to identify the main approaches in the training future teachers in in regard to cloud technologies, to determine the content of this training, methods and forms of its organisation, and to prove the effectiveness of their application.

According to IEEE Standard 802 11, approved by the IEEE Institute in 2008, cloud technologies, and more precisely, …*cloud computing* is defined as …*a paradigm in which information is permanently stored on servers on the Internet and temporarily cached on the client side* [4]. In addition, the emergence of the cloud computing paradigm as a technology of distributed data processing, has created a situation in which computer resources and capacities are provided to the user as an Internet service. It has contributed to the development of cloud computing from the …*infrastructure as a service* to *software as a service* cloud infrastructure management by the user; and therefore, the use of cloud services becomes relevant. All this allows the simplified use of cloud technologies in education, which entails the need for future computer science teachers to study cloud technologies. Virtualisation as the basic principle of organisation of cloud technologies is inherited from the virtualisation of servers and services. Cloud technologies allow virtualising work,

creating virtual data storages. Due to virtualisation, cloud technologies have great practical application in organising virtual laboratory classes, supporting virtual reality (VR) technology.

A study on the transition to the use of cloud technologies in education showed that today key technologies and tools are those that are built on the principles of cloud computing [5]. Accordingly, for the study outlined in this article, only technologies and instruments with the so-called cloud properties have been selected to the exclusion of other types that represented no pedagogical value for this study.

Thus, the possibility of supporting cloud technologies stands out as a new criterion for selecting tools and organising the educational process within the new cloud-based framework. This includes new conditions in the digital transformation of the education system. Henceforth in this article, this will be referred to as the *cloud* criterion. The *cloud* criterion implies the selection of means, methods and forms of education organised according to the principles of cloud technologies or computing.

LITERATURE REVIEW

The issues of introducing ICT into the education system have been considered by Lukyanova et al [6], Hakaka et al [7] and in various educational programmes [8]. Network services, and especially social networks, have been inspirational for academic educators in terms of capabilities and teaching applications. Distance learning technologies in education have been considered for several years. Today, the transition to distance learning is based on these approaches.

At the present stage of the development of digital society and the introduction of distance education, information and communication competence is essential for future teachers and it should be based on the use of cloud technologies. Cloud technologies as a component of Internet technologies, including Web technologies, imply the provision of on-line services to education. According to Elazhary [9], Al-Samarraie and Saeed [10], Arpaci [11], Moscicki and Mascetti [12], and Wang and Wang [13], the emphasis is made on the implementation of *cloud computing* in the higher education system. Accordingly, the direction to incorporate ICT into education is at the core of this study. Therefore, this study encompasses not only an insight into educational and innovation practices, in terms of ICT development and implementation in higher education institutions, but it focuses on an actual implementation of cloud technologies in the search for modern and effective ICT solutions in new educational paradigms [14].

MATERIALS AND METHODS

The experimental work was carried out in the Department of Computer Science and Applied Mathematics of Abai Kazakh National Pedagogical University, Almaty, Republic of Kazakhstan, in 2017-2020. The study involved about 100 Bachelor students majoring in *6B011100 - Informatics*. Students of non-pedagogical specialties in computer science also took part in the experiment. The total number of subjects was about 150 students. The study was carried out in three stages. At each stage, two groups were selected: experimental and control; each group included, on average, 33 students. For each group, the results obtained at the beginning and end of the experiment were taken into account.

At the beginning and end of the experiment, motivational, activity and cognitive criteria were used as a basis for evaluating the results. The identification of motivation for learning cloud technologies and readiness to use them was assessed using the questionnaire method. For this, an on-line cloud polling platform was used, which supports automatic processing of survey results and presents them in the form of diagrams and graphs. Assessment of activity and cognitive criteria was carried out according to the results of both the questionnaire, and students' laboratory work and their independent work.

Cloud technologies as a means of teaching a subject require a different approach. For that purpose, certain cloud tools and platforms for education in general and for teaching a certain subject in particular have to be selected. This approach is most suitable for virtualising those courses that involve laboratory-based work with real instruments and, accordingly, replacing them with a virtual laboratory using virtual instruments. This approach was demonstrated in many studies in various disciplines and for various specialties in addition to computer science and it is most accessible to subject teachers.

To obtain reliable findings, mathematical methods of educational research were also applied [15-19]. These methods were used to calculate the performance criteria in accordance with the main topics of the Cloud Technologies course. The calculation is based on determining the reliability of coincidences and differences for experimental data measured on an ordinal scale; the homogeneity criterion is used [17] (Equation 1):

$$\chi^2_{emp} = N * M * \sum_1^L \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{n_i + m_i} \quad (1)$$

RESULTS AND DISCUSSION

This study used a *combined* approach based on considering cloud technologies as an object of study in informatics and as a means of training teachers. The chosen approach requires the provision of topics related to the theoretical foundations of cloud computing, solutions to a number of pedagogical problems, as well as the possibility of

communication in the training of future teachers. Therefore, with this approach, the infrastructure management model on the cloud combines all management models. For the most part, these approaches resemble combinations of infrastructure management models on the cloud: IaaS + PaaS implements the ideas of the first approach, PaaS + / SaaS - the second, IaaS + PaaS + SaaS - the third, IaaS + PaaS + SaaS + CaaS - the fourth. Four different approaches with the corresponding infrastructure management models, main topics and cloud tools are presented in Table 1.

Table 1: Cloud learning approaches with the corresponding infrastructure management models on the cloud.

Approach	Infrastructure management model	Main topics	Cloud tools
CT as an object of study	IaaS+PaaS	- virtualisation technology - cloud computing - infrastructure management on the cloud - cloud computing levels - cloud deployment models - cloud administration - cloud services - cloud platforms - programming in cloud services - cloud-oriented software functionality and its protection, etc	Microsoft Azure, Google App Engine, Amazon, ownCloud, Google, Microsoft, Microsoft OneDrive, Google apps, Dropbox, Yandex, Cloud@mail.ru
CT as a learning tool	PaaS+/SaaS	- cloud services - pedagogical possibilities of using cloud technologies - issues of training teachers in cloud technologies	Microsoft OneDrive, Google apps, Dropbox, Yandex, Cloud@mail.ru
Cloud services as an object and a learning tool	IaaS+ PaaS+ SaaS	- cloud services and their classification - the basics of working with cloud services - the choice of cloud services and the associated risks - pedagogical possibilities of using cloud technologies - issues of training teachers in cloud technologies	Microsoft OneDrive, Google apps, Dropbox, Yandex, Cloud@mail.ru
CT as an object and a teaching tool	IaaS+ PaaS+ SaaS + CaaS	- theoretical foundations of cloud computing and technologies - the concept of the *cloud* and its types - cloud platforms and their organisation - cloud services and their classification - the basics of working with cloud services - deployment of *clouds* - the choice of cloud services and the associated risks - pedagogical possibilities of using cloud technologies - issues of training teachers in cloud technologies	Microsoft Azure, Google App Engine, Amazon, ownCloud, Google, Microsoft, Microsoft OneDrive, Google apps, Dropbox, Yandex, Cloud@mail.ru

The cloud computing paradigms discussed above and the principles of using cloud technologies in education in combination with the *combined* approach allow differentiating two main modules in the content of the Cloud Technologies course: theoretical foundations of cloud technologies and cloud technologies in education.

The first module, *theoretical foundations of cloud technologies*, reflects the content identified in the first approach, and allows revealing the essence of cloud computing and technology as an object of study. It teaches how to deploy and administer clouds. The second module, *cloud technologies in education*, reflects the third approach and considers cloud technologies and cloud services from the standpoint of solving pedagogical problems, mainly in teaching. A detailed content of the topics of each module is given in Table 2. In more detail, the principles of content selection were presented in earlier studies [18].

Table 2: The content of the cloud technologies syllabus for future computer science teachers.

No. topic	Module topics	Content
I	Module	Theoretical foundations of cloud technologies.
1	Cloud computing theory	Virtualisation technologies. Fundamentals and technologies of cloud computing. Classification. Examples. The difference between cloud computing and Web *.0 technologies.
2	Basics of working with cloud services	The basics of working with cloud services. Review of popular cloud service technologies. Examples. Cloud storage services Microsoft OneDrive, Google apps, Dropbox, Yandex, Cloud@mail.ru
3	Cloud deployment	Cloud deployment strategies. Cloud technology groups. Cloud platforms. Microsoft Azure. Characteristics of the SQL services group.

4	Virtual private cloud deployment	Private cloud features. Virtual cloud. Private cloud deployment technologies. Amazon, ownCloud.
5	Cloud service choices and associated risks	Recommendations for using specific cloud services. Organisational and legal framework for the use of cloud technologies. Recommendations for the use of specific cloud services in educational institutions. The advantages and disadvantages of this approach. Organisational and legal changes that may occur due to the introduction of cloud technologies into the educational process.
II	Module	Cloud technologies in education.
6	Cloud technologies in education and the management of educational institutions	A cloud-based learning tool system. Pedagogical possibilities of using the cloud in education and the management of educational institutions.
7	Cloud LMS systems	The concept of LMS. Classification. Moodle as a cloud-based education solution. The basics of working with Moodle on the cloud. Features of cloud administration using LMS.
8	The use of cloud technologies in the educational process	The use of cloud services in the teaching process and in the organisation of the teacher's work. Cloud services and self-education. Features of the organisation of distance learning using the cloud.
9	Building pedagogical cloud-based learning tools	Cloud-based learning tools in educational institutions. Classification. Development tools.
10	The use of cloud technologies in educational work	Interactive communication on social networks. Social media as a repository of data. Possibilities of cloud tools for organising the interaction of subjects of the pedagogical process.
11	The use of cloud technologies in the verification and assessment of learning outcomes	The use of cloud technologies in the verification and assessment of learning outcomes. Monitoring the quality of education. Cloud-based tools for the development of pedagogical monitoring tools. Portfolio. Organisation of a portfolio on the cloud.
12	Organisation of testing in the cloud	Internet testing. Possibilities of cloud services for organising testing. Cloud testing principles.
13	The use of cloud technologies in the management of an educational institution	Features of the organisation of management of an educational institution in the conditions of private clouds. Teamwork with documents in the clouds. Peculiarities of administration of private clouds in education.
14	Issues of training teachers in cloud technologies	Courses providing cloud education for teachers. Requirements for educators in the field of cloud computing.

The initial questionnaire *Student's readiness to use cloud technologies in education* helped to identify the level of ICT proficiency, the level and state of the students' hardware and software provision, and the degree of their independence. The specific questions were as follows:

- Do you use licensed/unlicensed software?
- Which of the cloud drives is installed on your computer?
- Which of the cloud drives is the operating system of your smart phone tied to by default?
- Which of the cloud drives is the operating system of your computer tied to by default?
- Do you use the cloud to store data?
- Do you use cloud services?
- and others.

As demonstrated in Table 3, an analysis of the state of technical teaching aids, software and students' ability to work independently revealed a weak level of technical provision of students with personal computers, laptops and other technical teaching aids. Students are practically not ready to study using cloud technologies. A weak level of independent learning was revealed, although some students know how to use cloud services.

Table 3: Results of the assessment of students' readiness to study cloud technologies.

Q: Do you use licensed/unlicensed software?	
Licensed	41
Unlicensed	14
Q: What operating system is installed on your computer?	
Windows 7	21
Windows 8	5
Windows 10	27
iOS	3
Unix	0

Linux	1
Q: Do you use cloud services?	
No	11
No, I have not heard of it	0
Rarely	30
Often	9
Constantly	4
I cannot do without them	0
I know about them, but do not use them	0

The second questionnaire *Learning outcomes of students in cloud technologies* was conducted at the end of the experiment. In this questionnaire, much attention was paid to the learning outcomes:

- What cloud services did you study in the course of training in cloud technologies?
- Do you use cloud services?
- Do you know how to deploy cloud services?
- Do you know how to open access to digital resources of your cloud for collaboration?
- Which cloud services did you use most often?
- What on-line services did you use when studying cloud technologies?
- Is it convenient for you to use cloud technologies and services for independent study including communication?
- How often did you start using cloud technologies and services?
- and others.

Selected results of this questionnaire are shown in Table 4.

Table 4: Results of the study of cloud technologies.

Q: Do you know how to deploy cloud services?	
No	40
No, others do it	5
Yes	9
Q: Do you know how to open access to digital resources of your cloud?	
Yes	29
No, others do it	3
Yes, but I do not use it	29
Q: Do you know how to open access to digital resources of your cloud for collaboration?	
Yes, but I do not use it	26
No, others do it	5
Yes	30
Q: It is convenient for you to work with shared resources on the cloud?	
At first it was scary, but then I have become confident	23
I am confident that it is convenient	24
I still have doubts	10
I still fear of data loss	4
Q: Would you like to study using cloud technologies in the future?	
Yes, in all courses	29
No, this is too much	4
Yes, only where it needed	24
No, I have not figured it out	4
Q: Have cloud technologies changed your preparation during the transition to distance learning?	
Yes, for all classes	22
No, learning recourses have to be on my PC	6
No, learning recourses have to be physical and not digital	9
Yes, I have begun to store learning recourses on the cloud	29
Yes, I have stopped using traditional means of accessing learning recourses	1

According to the calculations of the activity criterion and its comparison with the critical value, it can be concluded that the experimental and control groups are were in equal positions, both in terms of the available knowledge and of the technical equipment. The value obtained was 7.8 and it prevails over the critical value (5.1). Thus, the reliability of the experiment is 91%.

CONCLUSIONS

The findings presented above confirm the effectiveness of the proposed methodology for teaching cloud technologies to future computer science teachers at the Batchelor level. They show the possibility and availability of using cloud

technologies in training teachers, regardless of their subject area. They also reveal the effectiveness of the organisation of distance learning based on cloud technologies. Thus, well-organised learning using cloud technologies creates a digital educational environment that is applicable in traditional (off-line), blended and distance (on-line) forms of education. Within the framework of this study, the authors limited the scope to the traditional form of education. But due to the current pandemic, all educational institutions have been forced to adopt distance learning, which confirms the necessity of the introduction of the teaching methodology outlined in this article.

The level of teaching quality as a whole depends on how competently future teachers will use cloud technologies and services in teaching. For computer scientists, the study of services is not enough. Teachers must be able not only to use cloud services, but also to be able to deploy them, administer and implement them into the training system. A computer science teacher is both a teacher and a computer scientist. Thus, a teacher must be able not only to administer the cloud services, but also to use them to solve educational problems that have already become fundamental.

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