

## Cloud services application ways for preparation of future PhD

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**Abstract.** Currently, it is important in Ukraine to harmonize cloud technologies application with European and world scientific initiatives. Need to modernize preparation of future PhDs is caused by challenges of new information, globalized society and digital transformation of all spheres of life, including education and science. The research was aimed to determine features of cloud services application in preparation of future PhDs. Concepts of “cloud computing”, “cloud technologies”, “cloud learning technologies”, “cloud services”, “cloud oriented environment” were analyzed. Experience of cloud technologies and their services application in educational and scientific space in researches of foreign and Ukrainian students was considered. Ukrainian experience in preparation of future PhD of various specialties with cloud services application was analyzed. It was emphasized that approaches improving to preparation of future PhDs based on cloud services application would increase their level of digital competence. It is recommended to include a separate course or module of specific discipline on work with cloud technologies and services during preparation of future PhDs. It is important to improve disciplines and tools content to support education process. It can be learning of disciplines using cloud technologies or services by future PhD’s. Also, cloud services application to support scientific and scientific-organizational activities will increase level of organization and implementation of scientific research. It is important to create cloud-oriented environment for preparation of future PhDs in higher education and research institutions. Making cloud-oriented educational and scientific environment should be based on principles of open education. It is recommended to use cloud-based platforms and services (G Suite for Education; Microsoft Office 365; specialized SaaS (CoCalc or other)).

**Keywords:** cloud services, cloud-based learning environment, future Doctor of Philosophy.

## 1 Introduction

### 1.1 The problem statement

Problems of digital transformation of society in Ukraine are very topical. It is important that scientists and IT companies participate in EU long-term research projects. In future they will be source of innovation in such segments such as: Future emerging technologies; Future networks; Future internet research and experiments, etc. Main task of the research is to create experimental base for conduction of researches and testing of quantum technologies on distributed grid and cloud infrastructures in field of software engineering (application of things fir Internet, big data, artificial intelligence). In order to ensure efficient participation of Ukraine in European research and innovation space it is important to develop our own scientific digital infrastructure in accordance with priority areas where high-tech growth is expected. Connecting Ukrainian scientific digital infrastructures to European Open Science Cloud and European Data Infrastructure will give impulse to solve current Ukrainian scientific problems with minimal use of state resources [5].

Researches carried out in higher education and scientific institutions are directed on partial solution of issues listed by future PhDs. Nowadays development of scientific training system is an integral factor in scientific and technological progress of society. Mastering of modern achievements in the development of production and information technologies leads to new tasks for preparation of specialists of higher qualification, modernization of educational structure and qualification levels, updating of requirements for third degree – Doctor of Philosophy (PhD). Further search for efficient approaches to training of scientific personnel aimed at achievement of modern world levels by science and education and increasing of state intellectual capacity of the are important and relevant [42].

We emphasize that use of information and communication technologies is not fully implemented in the process of preparation of postgraduate and doctoral students. It happens because these technologies are mostly used to search information sources and text of dissertation, but other aspects of research are still performed in traditional way. Modern realities of society digitalization already dictate new tasks for preparation of graduate students and doctoral students, one of which is use of information and communication technologies not only for results design of dissertation research, but also for fulfillment of its individual components.

There is a problem of accessibility and ways of learning and supplying resources to achieve better pedagogical effect of their use. This problem can be partially solved by using of cloud computing power. The main benefit of cloud technology is improving access to quality resources (and sometimes it is only the way to access resources needed for everyone) [30]. The research [37] states that creation of high-tech cloud-based learning environment will integrate educational resources for educational purposes and support research. It will cover different levels of specialists training. In its turn it could help to address these issues, bridge gap between process of scientific search and level of implementation and use of its results.

We agree with the research [28], and believe that cloud technologies mostly meet needs of solving urgent social, educational and cultural problems of modern society. The problems include: increasing of availability and quality of education, interconnection of research processes and training of scientific-pedagogical personnel, improvement of designing, formation and maintenance of functioning of educational and scientific environment of pedagogical educational institutions. These promising technologies are instruments for human-centrism principles implementation, equal access to results of scientific research on learning materials [28]. Therefore, it is important to teach postgraduate and doctoral students to use cloud services to perform scientific research. It will have a positive influence on development of their information and communication competence.

## 1.2 Literature review

Ukrainian scientists emphasize importance of information and communication technologies using for digital transformation of society in their studies: for public administration [8; 34; 35], for ecology [31; 32], for education [4; 25], etc. Cloud technologies and services application for educational and scientific purpose was investigated by:

- domestic scientists: Valerii Yu. Bykov [3; 4], Olena H. Hlazunova [6], Olena H. Kuzminska [25], Nataliia V. Morze [25], Svitlana H. Lytvynova [13], Yuliya H. Nosenko [2; 28], Maiia V. Popel [15; 28; 30], Mariya P. Shyshkina [3; 28; 36; 37], Serhiy O. Semerikov [16; 22], Andrii M. Striuk [17; 43], Tetiana A. Vakaliuk [47] and others.
- foreign scientists: Anca Ioana Andreeescu [19], Prashant Kumar Baheti [38], Li Hao [48], Anjali Jain [11], Jia Li [48], Marinela Mircea [19], Upendra Singh [38], Guolei Zhang [48] and others.

Preparation problems of postgraduate students and doctoral students were considered by: Tamara I. Koval [12], Iryna Yu. Reheilo [33], Svitlana O. Sysoieva [12], Yana V. Topolnyk [45] and others. Preparation experience of postgraduate and doctoral students in the scientific specialty “Information and communication technologies in education” is described in [40; 41; 42]. Various aspects of using cloud services in postgraduate training require further study due to constant improvement of information technologies.

## 1.3 The aim of the research

Publication aim – is research of cloud services using features in preparation of future PhDs.

## 2 Research results

### 2.1 Main definitions and terms

Following terms are important for the given research: “cloud computing”, “cloud technology”, “cloud learning technology”, “cloud services”, “cloud oriented environment”.

Today, global companies and public institutions in the world invest in advanced digital technologies: mobile communications, social networking, big data analytics, “smart” devices that control objects and sensors connected to them, and others. Cloud technologies are used by organizations around the world and play a special role. Cloud computing was recognized as a priority in technological development, as evidenced by number of international instruments (European cloud computing strategy, US Federal Government cloud initiative) and government initiatives in various countries. These countries launched large-scale educational projects in USA, Japan, Russia and European Union, numerous international conferences and scientific publications. Therefore, problems of cloud computing services and technologies designing for use in educational process of educational institutions are very important in the field of informatization [37].

The US National Standards Institute (NIST) defines concept of “cloud computing” as following – it is as a model of convenient network access to common computing resources (e.g., networks, servers, data files, software and services) that can be quickly given by minimal efforts and interaction with supplier. Also the NIST developed recommendations that outline five basic characteristics of cloud computing. These characteristics allows to distinguish these systems from other types of ICT. They include: free network access; self-service on demand; pooling resources (location-independent); measurability of service (payment upon delivery); fast elasticity (provision and releasing of resource in necessary amount and at any time” [18].

Definition of “cloud computing” is known as “NIST definition” (The NIST Definition of Cloud Computing). According to this definition cloud model supports high availability of services. It is described by five main characteristics (self-service on demand; pooling resources; measurability of service; fast elasticity, regulated by four deployment models (private cloud, community cloud, public cloud and hybrid cloud) [16].

In 2009 Gartner’s reporting materials described cloud technology as “another super-concept among ICTs that has hopes for (“Cloud Computing is the latest super-hyped concept in IT”). Cloud technologies are considered as simple idea according to the report. But there are many issues regarding types of cloud technologies or scale of their deployment that make them not so simple [16].

Ukrainian scientists, in particular Valerii Yu. Bykov defines concept of cloud technology, through the concept of “virtual network platform”. Networked virtual ICT objects are formed in adaptive information and communication networks due to a special user interface, supported by system software networking tools. Such objects – network virtual sites are situational component of logical network infrastructure of information and communication networks with temporary open flexible architecture,

which in its structure and time of existence meets personal needs of user (individual and group), and their formation and use of technology [4; 36].

Author [16] defines concept of “cloud technology” (cloud information and communication technology) as a set of methods, tools and techniques used to collect, organize, store and process on remote servers, transmission over the network and submission through a client program of all kinds of messages and data. Cloud technologies are a subset of information and communication technologies. ICT learning is a subset of learning technologies. So, “cloud learning technologies” are such ICT training that involves use of cloud ICT. It can easily be defined as network ICTs, providing centralized network storage and data processing (execution of programs), for which user acts as a client (user of services), and “cloud” – is a server (service provider) [16].

Also, “cloud services” are services that provide user with network access to scalable and flexibly organized pool of distributed physical or virtual resources delivered in self-service and on-demand administration (e.g., software, storage, computing, and computing capabilities) – defined in [10].

According to [37] “cloud-oriented environment of a higher education institution” means the environment created by educational and scientific process participants in this institution where a virtualized computer-technological infrastructure is purposefully developed for implementation of computer-processing functions. Cloud services should be used to make available to user electronic educational resources that make up meaningful content of a cloud-oriented environment, as well as to provide processes for creating and supplying educational services [37].

## **2.2 Experience of cloud technologies application and their services in educational and scientific space**

In the first time cloud technologies in a higher education institution were applied at the University of Maryland [7]. Amazon Web Service was deployed (corporate cloud deployment services to support IT infrastructure, for example, to train software design courses) [37].

More coordinated approach to development of research networks and infrastructures was pursued in European education area, in particular in creation of the European strategy forum on Research infrastructures. In 2013 the European Commission released concept paper “Digital Science” outlining basic principles of vision for development of digital science, including cloud, as well as integration into the Horizon 2020 program. Integration of ICT in research process should be aimed at development of Internet culture, based on principles of openness, social significance and broad cooperation. Science is becoming more global, more creative and closer to society. “It is a science that relies on e-Infrastructures, mainly to: develop and disseminate specific ICT tools to solve scientific problems; providing prompt online access to scientific resources, including publications and data; creation and development of platforms and tools that enable large-scale collaboration without need for physical presence” [37].

Experience of Massachusetts Institute of Technology in the context of using educational software in a cloud-based educational environment to deploy cloud access

to mathematical application packages (Matlab, Mathematica, Maxima, Maple, R) is interesting. Hochschule Furtwangen University deployed corporate cloud-based infrastructure called Cloud Infrastructure and Application (CloudIA). Target users of this infrastructure were university staff and students who used it to launch educational applications and communicate with colleagues outside the university to organize collaboration. So, it's about deploying a corporate cloud. As a rule, to get services for supply of resources and services on a cloud model people appeals to major providers such as Google, Amazon or others [37].

Also, researches of foreign scientists [1; 11; 14; 18; 19; 38; 48] describes experience of cloud technologies and services using for higher education needs.

Ukraine moves towards information society and information technologies. They are actively implemented in all spheres of public life. However, this movement is slow compared to global. Lack of unified state policy and coordination caused chaos in electronic systems. Widespread use of Internet in everyday life requires thorough methodological analysis of Internet impact on interaction of public institutions with general public [34]. Publication [8] describes problems that slow down necessary social development and demonstrate difficult situation in Ukraine instead effective social dialogue between the state and society, government and citizens.

This issue is reflected in the Concept of digital economy and society of Ukraine for 2018–2020 [5] at the state level. The Concept foresees implementation of measures on appropriate incentives for digitization of economy, public and social spheres, awareness of existing challenges and tools for development of digital infrastructures, acquisition of digital competencies by citizens, and identifies critical areas and projects of digitization, promotion of internal market for production, use and consumption of digital technologies. One of the important tasks is to formulate national policy for digitizing education as a priority component of education reform. Digital education is integration of various components and modern technologies by use of digital platforms, introduction of new information and educational technologies, use of progressive forms of organization of educational process and active teaching methods, as well as modern educational and methodical materials [5].

The [5] also states that integration of Ukrainian science into European research space will enable the of advanced scientific ideas, participation in interdisciplinary projects focusing on promising ideas, technologies and innovations. One of the important elements of Digital single market in Europe and part of paradigm “Open innovations – Open science – Open world” within the European Research and Innovation Area is development of European open science cloud and European data infrastructure.

Basic postulates implementation of the Concept described above has been realised for some time in Ukraine. After analysis Ukrainian scientists' publications we recognize that researches can be grouped as follows:

- introduction of ICT in training of specialists in various specialties [6; 9; 20; 21; 23; 24; 41; 44], in particular cloud services [2; 30; 37; 47];
- use of cloud services for scientific research [28];
- deployment of cloud-oriented environments of educational institutions [3; 29; 36; 37].

Experience of using cloud services and cloud technologies in educational process of Ukrainian educational institutions is described in [3; 29; 36; 37; 39].

Dissertation [6] explores use of cloud services in supporting research and deployment of cloud-based environments based on open ICT platforms. Comparative analysis is conducted and experience of implementation of different deployment models of cloud infrastructure both on basis of the educational institution and lease of infrastructure from service provider is summarized, in particular, deployment cost aspects are covered.

The research [39] emphasized that use of cloud services by a lecturer will contribute to: preservation of educational material and its use anywhere and at any time; use in educational research, for example in mathematical disciplines; organization of teamwork and individual work with use of appropriate tools; applying various forms of control and evaluation of academic achievements of a group of students.

Cloud services are considered as learning tools in addition to mobile learning tools in recent publications [39; 43] investigated a number of cloud services that are proposed to use in education process in combination with traditional learning tools: G Suite for Education, Office 365, ThinkFree Online. In particular, cloud services are characterized, their characteristics and constituents are highlighted and advantages of their use as a means of learning mathematical disciplines are underlined [30].

The research of [30] describes an experimental study on use of CoCalc cloud service in learning of mathematical disciplines. It is suggested to use CoCalc for preparation of future Math teachers. CoCalc is a free service supported by the University of Washington, the National Science Foundation and Google. CoCalc was designed specifically to make it easier to use mathematical calculations on the Android platform. CoCalc implements all features of SAGE Web SCM, but there are some differences. Principle behind CoCalc is to build one-on-one or group projects, fill them with learning resources, and work with individual or group resources at the same time. The system also preserves user actions that are displayed in chronological order. It is possible to display work history with a particular learning resource (or project) of both specific user and group of users. Making certain changes to each project leads to structure backup of the project. All copies are stored in chronological order, indicating author of changes [30].

The research [37] indicates that development of cloud technologies creates a significant need to review approaches of development and delivery of ICT services in terms of their integration. It also concerns teaching methods of information science. Use of cloud-oriented resources, information and communication platforms in various disciplines teaching in higher education becomes an urgent need for modernization of pedagogical methods and technologies, since it indicates transition to new models of organization of educational and professional activities which are based on availability of electronic resources. It is important to use hybrid service models and infrastructure solutions that combine different public and enterprise services on a single platform. Use of hybrid models is particularly promising for education sector [36]. Numerous universal cloud-oriented applications and services find their place in educational process. They include cloud-based tools like Microsoft Office 365, Google Apps, and others. Most of types in this type contain a set of “office” functions that can be used to

support different types of educational and research activities: it is a corporate email and calendar for planning and organizing events by a specific group or training community; tools for processing online office applications such as Word, Excel, Power Point, etc., which allows both collective and individual work with certain educational materials contained in the cloud storage (One Drive, Google Drive); creating groups to share documents and their collections; an electronic note (One Note) for recording both individually and collectively; Web conferencing (Skype or other) by means of which you can organize video conferencing, voice or chat with participants or with a group, etc. There is also a wide range of cloud services, such as online photo and video editors, web page editing tools, translation services, spell checking, borrowings in text, and others [36].

VMware cloud-based virtualized environment is used to support problem-solving, collaboration and teamwork. Virtualized learning environment makes ability to quickly create computer labs of all kinds, depending on requirements for different IT courses, making it flexible, scalable and accessible online. It happens without increasing of load on equipment. Students can make mistakes during learning of new technologies which could harm servers, networks, or databases. It is much easier to recover virtualized cloud-based environment using backup versions. With virtual servers and virtual networks, students receive opportunity to make experiments [37].

Cloud services should be used to support IT training and deployment of cloud-based computer labs for various types of IT courses. Maintaining IT training labs is especially convenient with cloud technology support, given very fast-paced types of IT industry development. It is flexible and dynamic tool for customizing environment to suit your learning needs. It is advisable to use cloud services to create virtual machines that can be used for variety of courses during development of virtual labs. They can be used to support training courses such as web design or database development, system administration, and other [36].

The research [47] investigates theoretical and experimental issues of designing and use problem of cloud-oriented educational environment in preparation of bachelors on informatics.

Modernization of educational and scientific environment of university on the basis of cloud technologies and introduction of cloud-oriented platforms of ICT services supply is a subject of consideration and careful attention of scientists [37].

Modernization and development of educational and scientific environment of educational institutions are among the pressing problems of modern education reforming. Introduction of cloud services and technologies lead to formation of new areas of scientific and pedagogical researches. These researches are related to submission of electronic resources and services. Cloud technologies correspond to needs of solving urgent social and educational and cultural problems of modern society: increasing of accessibility level and quality of education, interconnection of processes of scientific research and training of scientific and pedagogical personnel, improving design, formation and maintenance of educational and scientific environment of pedagogical educational institutions. These promising technologies are an instrument for implementation of the principles of human-centrism, equal access to training [28].

One of the most important factors in deployment of cloud-based environment in different fields of activity, including education, is need to standardize requirements for cloud-based ICT. A number of documents in field of cloud-based ICT standardization were adopted or proposed for discussion [37].

Formation of cloud-oriented educational and scientific environment in higher education institutions and scientific institutions is an essential precondition for preparation of ICT-competent specialists, capable to further activities and scientifically grounded application of cloud technologies in their professional activity [28]. Efficient implementation of cloud services in an educational institution requires special training, introducing its relevant elements to content of training, retraining, advanced training of scientific and scientific-pedagogical staff, graduate students and doctoral students. Training content should be aimed at developing of competencies of researchers, graduate students and doctoral students in the use of various cloud-oriented systems and services in research and educational process [28].

We agree with research [37] that emergence of high-tech platforms, in particular on basis of cloud computing, adaptive information and communication networks, virtual and mobile training is a certain step towards solving problems of accessibility and quality of learning. It changes perception of infrastructure of organizing learning process and its content. Insufficient number of highly qualified personnel and lack of strategic approach to ICT infrastructure design of higher education institutions is one of reasons for lack of systematic decisions of higher education informatization. It impedes creation of single high-tech platform.

Nowadays, universities can play a key role in shaping regional strategies and setting priorities for local specialization, taking into account intellectual resources, skills and competences of research and production personnel existing both within university structures and in local business. Unification and integration processes are realized through creation of inter-university corporations and consortia, which are based on networked distributed structure of staff training and skills development [36].

Ability to access remote educational resources on-line appears on the basis of modern network technologies. For example, it can be implemented using virtual labs and remote access labs, cabinet resources, and university labs for demonstration experiments. Also, ICT tools and technologies got further development based on cloud computing concept. This concept substantially changes existing perceptions of access organization and application integration. So, it is possible to manage large ICT infrastructures that allow creation and use of individual and collective “clouds” within a shared cloud-oriented educational space [37].

Well-known IT service providers offer some cloud services for training purposes: 1) IBM Blue Cloud offers tools to support migration of data from traditional IT infrastructure to a cloud called IBM Cloud Academy (IBM, 2009); 2) Google App Engine launched G Suite for Education program (Google, 2010) to support educational institutions; 3) Microsoft Windows Azure offers cloud solutions for educational institutions (Microsoft, 2011). All kinds of services can be used – IaaS, PaaS and SaaS [37].

A separate research way appeared on use of cloud technologies in supporting of common team work of programmers on code development. This was called “virtual

computer labs” (VCL). The authors define this term as technology that can be used to deploy distributed small data centers and IT services for educational institutions (mostly used to build IT-based educational laboratories). One of the basic structural units of cloud-based educational environment is personalized remote-access training and science laboratory. This term is defined as set of interactions between participants in learning process, content elements and other elements of online learning environment with personalized access to all available resources and services from a remote location. Also, there are cloud versions of well-known manufacturers of service providers, including CoCalc, Maple, MATLAB, MapleNet, MATLAB web-server, WebMathematica, Calculation Laboratory and others [36].

Cloud computing applications allow you to deploy tools that can be scaled for any number of users. Often users use clouds (cloud services) without even knowing it [25].

The research [37] determined that basic characteristics of information and technological infrastructure formation of educational and scientific environment, approaches to design of corporate information systems were changed due to cloud computing tools and services. These changes affect organization of scientific and educational activities. Such activities can be improved with use of new models and approaches. Involvement of scientific and educational community in ICT and networking tools of open information and educational space can play a leading role in addressing these issues. These tools capacity significantly increased due to cloud computing services. Use of information-analytical network tools and services of cloud computing is very important in informatization sphere of education, development of open scientific and educational space.

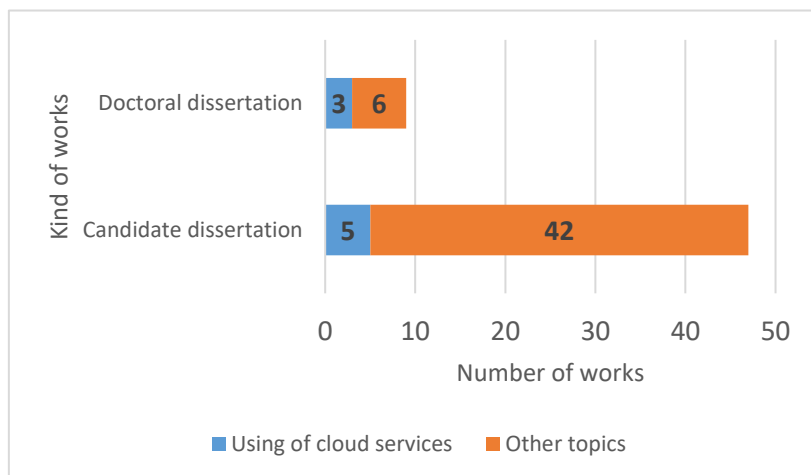
### **2.3 Native experience analysis of postgraduates training using ICT (cloud services)**

It is necessary to conduct appropriate training, introducing its relevant elements to content of training, retraining, advanced training of scientific and scientific-pedagogical staff in order to implement cloud services in an educational institution or scientific institution. Training content should be aimed at ICT competences building of lecturers, staff of ICT departments, graduate students and students in use of various cloud-oriented systems and services in research and learning process [28].

Innovations introduction into educational and scientific environment is significantly conditioned by availability of engineering, technical and pedagogical staff for informatization of educational systems of different levels. Special staff is needed to provide information processes – implementation and development of ICT training technologies. In connection with this, an education informatization staff is a significant group of players in the cloud-oriented environment in connection with listed above [37]. The work [37] defines “scientific-pedagogical staff of education informatization” as workers who work with organizational-normative, socio-economic, educational-methodical, scientific-technical, production and administrative support of processes aimed at meeting information and telecommunication needs (other needs related to ICT tools and methods implementation) by participants in learning process. Key categories of scientific and pedagogical staff are lecturers, management staff (heads of ICT units)

and employees of educational management bodies concerned with widespread adoption and use of ICT in learning. ICT competences of education informatization staff are central in their preparation because their field of activity lies in innovative technologies [37]. Training and certification of such personnel should be systematic and planned. Therefore, we will present experience of the Institute of Information Technologies and Learning Tools of NAES of Ukraine (IITLT of NAES of Ukraine), which provides training, certification and professional development of education and science informatization staff.

It should be noted that in 2008 the IITLT of NAES of Ukraine staff developed a passport of new scientific specialty 13.00.10 – “Information and communication technologies in education (industry – pedagogical sciences)”. In 2009 the passport of new specialty was approved and included in the list of specialties under which defense of dissertations is carried out to obtain scientific degrees of candidate and doctor of sciences (PhD) and assignment of academic titles. Later in 2010 the IITLT of NAES of Ukraine opened postgraduate studies in Ukraine for the first time, and since 2011 – doctoral studies. From 2011–2018, more than 47 PhD and 9 doctoral theses on the new specialty were defended at IITLT of NAES of Ukraine [41]. Figure 1 shows a graph on number of defended dissertations with highlighting of works explored use of cloud technologies and services for educational and scientific purposes. From this graph it is clear that only 11% of candidate dissertations and 33% of doctoral dissertations explored features of use of cloud technologies and services and deployment of cloud-oriented environment in educational institutions. Therefore, such studies are relevant and promising.



**Fig. 1.** Number of defended dissertations on use of cloud technologies and services for educational and scientific purposes in relation to the total number of defended scientific works

In 2016 leading scientists of the IITLT of NAES of Ukraine were involved in development of educational-scientific program “Information and communication technologies in education” for training of specialists of the third (educational-scientific)

level of higher education on the specialty 011 “Sciences about Education”. A number of legislative and regulatory acts provisions concerning preparation of PhD students were taken into account during development of methodological recommendations of educational program. Amount of time for preparation for educational component of education program is 32 ECTS credits (31 – for learning of disciplines, 1 – for the final certification), term of study – 4 years. The program is implemented in following forms of study: full-time (day and evening) and part-time (distance). Purpose of future PhD students training in program “Information and communication technologies in education” is to prepare specialists with in-depth theoretical knowledge, practical skills and competences. The specialists should be able to solve complex problems in the field of ICT in education and to carry out research in this field. Ability to solve complex problems in the field of professional and/or research and innovation activities should be formed at applicant during postgraduate study. It involves deep rethinking of existing and creation of new holistic knowledge and/or professional practice [41].

Educational-scientific program of PhD training on the specialty “011 Sciences about education” (program “Information and communication technologies in education”) at IITLT of NAES of Ukraine consists of compulsory disciplines and disciplines at the graduate student choice. It includes:

1. Disciplines of the general training cycle (“Philosophy of education and methodology of educational research”, “Foreign language and academic writing”, “Organizational and project research and innovation activities in education”, “Teaching in modern higher education”).
2. Disciplines of vocational training cycle (“Cloud oriented technologies for supporting scientific and educational activities”, “Scientific bases of ICT using in education”, “ICT training, management and support of scientific and educational research”).
3. Selective disciplines of vocational training cycle (Block A. “Information technologies in education and research”, “Scientific electronic communications and open journal systems” and Block B. “Education and learning systems in a computer-oriented environment”, “Scientific electronic libraries and scientometrics”) [42].

After analysis of curriculum for preparation of future PhDs we determined that study of cloud technologies and their services is a separate discipline. Also other disciplines contain certain modules and topics that involve use of cloud services and further work with them. Number of cloud services are also applied to managing process of graduate student preparation.

Current state of development of educational and scientific environment is characterized by increasing requirements for quality of electronic resources for scientific and educational purposes; expansion of more flexible, personalized, open organizational systems. It becomes possible with use of cloud information and communication platform services. Involvement of open-source networking technologies with recently grown capacities in educational institutions can play a leading role in deepening of links between education, science and production; expansion of cooperation between educational and scientific institutions; creation of various corporate structures (branches of industrial establishments, training and engineering centers, etc.) aimed at developing of closer interaction with higher

education sector, broader participation in solving urgent social and economic problems, improving the intensity of scientific research and training [28]. Therefore, the IITLT of NAES of Ukraine cooperates with a number of higher education institutions in Ukraine. They create joint research laboratories and cooperation agreements. In framework of these agreements future PhDs may conduct their own experimental research at higher education institutions and conduct teaching, organize and hold joint events (conferences, seminars, etc.). The IITLT of NAES of Ukraine cooperates with National Aviation University (NAU) because NAU is going to start preparation of masters on specialty “Information technologies in education”. Also, NAU plans to deploy a cloud-oriented environment for effective master’s and PhD preparation.

Let’s consider advantages of using cloud services in educational process of higher education institution and scientific institution, in particular for preparation of masters and future PhD.

Nowadays, it is important to improve educational and scientific cooperation through shared access to electronic resources – scientific and educational networks and open information systems (libraries, open journals and video conferencing systems, etc.). There is movement towards use of open systems of research. It is characterized by such innovative characteristics as better adaptability, mobility, full-scale interactivity, free network access, uniformity of infrastructure and others. At the same time, cloud-based electronic research infrastructures are implemented through use of cloud services of relevant ICT platforms. Cloud-oriented enterprise information systems can be understood as providing tools for supporting educational activities and research (computing power, storage space or network resources for interconnection, etc.) and are implemented on the basis of cloud services. New models of activity are formed due to introduction of cloud technology in education. It influences content, methods and organizational forms of open education [37].

We support opinion in [37] that “cooperation of universities with academic organizations and business structures, processes of training and professional development of personnel, implementation of international projects, realization of links between schools and higher education institutions can be realized within the network interaction framework”.

We analyzed the work [30; 36; 43] which describes general trends in formation of cloud-oriented educational environment: removal of restrictions on access from any device, anywhere, anytime; development of personalized learning environments; developing a service-oriented approach, increasing the number of SaaS; improvement of teamwork services (videoconferencing, access to shared content); introduction of unified ICT infrastructure of educational institution, increasing use of IaaS; development of hybrid service models, use of both corporate and public resources, integration of services; increasing requirements for interoperability, reliability, security and other dissemination of the “big data” approach in design of pedagogical ICT systems; reducing licensing and maintenance costs.

Using of cloud services contributes to achievement of new level of education quality; potential creation for individualization of the learning process; formation of individual trajectories for development of students; selection and use of appropriate technological tools. Compliance of ICT tools in higher education information and education

environment with a number of requirements for support and management of resources, interface design, ergonomics and others is a necessary condition in the given case. In addition, innovative educational technologies must meet certain systemic pedagogical and information-technological requirements. They are dictated by level of scientific and technological progress. Requirement should meet principles of open education [37].

Modern technologies are aimed to support different types of lecturer activities in virtual environment. It is connected with formation of groups, communities that learn and interact virtually in real time. We use features that provide collective access to training content for a user group, lecturer ability to browse all computers in the group, concentrate students through messages, connect or disconnect participants in the learning process, share files or links among the target group, send messages to specific students to organize activities in such communities. Students can also ask questions, comments, and more. Cloud platforms and services (WizIQ, OpenClass, VideoWhisper etc.) can be used to train and organize virtual classroom activities. Also, there are new forms of work with services and applications that lecturers can use in educational process. They include virtual classes (Whiteboard, Breakout rooms), cloud-based application collaboration systems, web conferencing (web tours, webinars), online distance learning platform (Google Open Class, Canvas); G Suite educational apps (Gmail, Calendar, Blogger, Groups, Maps, Reader, YouTube, Talk) and more [36].

Proper material conditions are important to ensure training of highly qualified scientific personnel. The IITLT of NAES of Ukraine created appropriate conditions for implementation of educational and scientific process, work of graduate students and supervisors: area of free access to Wi-Fi, which extends to all premises; workplaces of academics are connected to Internet and equipped with webcams for on-line counseling; training spaces are provided with multimedia complexes [41]. Cloud-based environment for preparation of future PhDs is created. It includes deployed cloud with Office 365. CoCalc and Google services are actively used.

In the research [28] it is recommended to use Google cloud services. The main benefits of Google services for higher education and research institutions are following: free of charge; reliability (reliable data storage, crash protection, etc.); there is no need to deploy a cloud; intuitive interface, easy to use; availability of universal account that provides access to all services; availability of extensive functionality that is constantly updated and capable to provide support for virtually all activities of the institution; availability from any digital device connected to the Internet (on “anywhere”, “anytime basis); ability to use different platforms (Windows, Android, iOS, etc.). Using Google services to perform research covers such matters as: planning and organization of work; professional communication; search and analysis of scientific sources; electronic workflow; data retention and sharing; conduction of on-line surveys and processing their results; dissemination research results and monitoring their implementation [28].

There are some of issues that can be solved by use of Google services:

1. Selection of source base of study (foreign and domestic literature).
2. Drafting and preparation of manuscript of dissertation or scientific article.
3. Conduction of on-line surveys.

4. Organization and management of process of preparation of graduate and doctoral students.

So, Google Cloud Services is a good fit for future PhD preparation (Gmail, Google Search, Google Docs, Slides, Sheets, Google Calendar, Google Drive, Google Scholar, Google Books, Hangouts, Google Forms, Google Keep, Google Sites, Google+, Blogger).

Development of network technologies leads to possibilities expanding of educational, professional and interpersonal communications. It enables efficient information and communication support to activity of future PhD. So, the IITLT of NAES of Ukraine uses cloud services, electronic social networks to support communications with graduate and doctoral students. Newsletters of conferences, invitations to seminars and other are sent to different group of people using Gmail mail service. Mailing list includes postgraduate students. Google Calendar is actively used to disseminate current events and events of the IITLT of NAES of Ukraine [42].

Important condition for preparation of future doctors of philosophy is approbation of dissertation research results during scientific mass events: forums, conferences, seminars, round tables, pedagogical readings, etc. The IITLT of NAES of Ukraine has conducted the All-Ukrainian Methodological Seminar for Young Scientists “Information and Communication Technologies in Education and Research” for postgraduate students and PhD students since 2013. This seminar is attended by representatives of various scientific and higher education institutions of Ukraine, and graduate students of the Institute. The All-Ukrainian Scientific-Methodological Seminar “Systems of Education and Education in Computer-Oriented Environment” has been held since 2011. It is aimed to cover results of completed dissertations before considering them by specialized scientific council. Also, the International Scientific and Methodological Internet Seminar “Cloud Technologies in Education” (‘CTE’) is held annually. Its results are published in English [41].

### **3 Conclusions and prospects for further research**

Need to modernize preparation of future PhDs is caused by challenges of new information, globalized society and digital transformation of all spheres of life, including education and science.

So, following conclusion are done after analysis of scientific sources:

1. Cloud services are aimed on the following: increasing of users access to the best samples of electronic educational resources and services; personal development; potential obtaining of maximum possible results of use of ICT to achieve learning objectives. Making of cloud-oriented educational and scientific environment should be based on the following: principles of open education (mobility of students and teachers); equal access to educational system; provision quality education; formation of structure and realization of educational services; general pedagogical principles: adaptability; personalization of service delivery; unification of infrastructure; full-

scale interactivity; flexibility and scalability; standardization and compatibility; safety and reliability; innovation, etc.

2. Improving approaches to preparation of future PhDs based on use of cloud services will increase level of digital competence in them. It is recommended to introduce specific course or module in specific discipline for working directly with cloud technologies and services. It is possible to improve content of disciplines to support educative process – to teach courses using cloud technologies or services. Also, use of cloud services to support scientific organizational activities will increase level of organization and implementation of scientific research.
3. It is important to create cloud-oriented environment for future PhDs preparation in higher education and research institutions. Such educative environment should meet following characteristics: accessibility and mobility; openness; integrity and continuity of higher education; systematicity; consistency and structure; innovation; integration with cloud-oriented resources; clearness; functionality; collectivity; provision of project activities; scientific aspect; reliability; supporting of communication processes; flexibility and adaptability; individualization; completeness of information resources; convenience; expediency.
4. It is recommended to use cloud-oriented platforms and services (G Suite for Education; Microsoft Office 365; specialized SaaS (CoCalc or other); public cloud services based on ICT platforms (Amazon Web Services, Microsoft Azure or other), corporate services Clouds based on ICT platforms (Microsoft Azure, Xen, VMWare, etc.). Among Google's cloud services, we recommend following: search service (Google Search); communication services (Gmail service, Google Groups); surveys (Google Forms); office suite (Google Docs, Sheets, Slides); planning and organization support service (Google Calendar); data storage and document sharing (Google Drive); professional development and source search services (Google Books, Google Scholar); communication and feedback services (social networks). Thus, cloud services use will increase level of organization, implementation of research results. Also it will increase level of digital competence of reporting process subjects of (PhD students, department heads, research and teaching staff).

Further research requires practical aspects of using cloud services and open access electronic systems in preparation of future PhDs.

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