

# Cloud-oriented systems for open science: supporting virtual research teams through adaptive content management and collaboration tools

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## Abstract

The article considers the peculiarities of forming virtual systems of open science in higher education institutions, which is an essential prerequisite for training ICT-competent specialists capable of active, practical, scientifically justified application of the most modern ICT in their professional activities. The modern European trends in the formation of cloud-oriented systems of open science in higher education institutions are considered; the experience of implementing the services of cloud-based systems of open science to support the processes of scientific cooperation within “V4 Educational Academic Portal for Integrating IT into Education” (EDUPOINT) is summarized; the prospects of using cloud-based platforms and adaptive content management services in the activity of a teacher and scientist are determined. The cloud-oriented IT support system for research activities of a virtual scientific team of the EDUPOINT project consists of network ICT infrastructure, educational software WPadV4 and PIKS channels – online application (PHP/MySQL) – personal information and communication system of project participants. The experience of using this cloud-oriented open science system to support communication; joint work; adaptive content management; creation and use of electronic educational resources in organizing educational and scientific cooperation in virtual international teams created based on several higher education institutions is summarized. It was established that due to the broader involvement of means and services of scientific and educational cloud-oriented platforms in the educational and research process of higher education institutions, as well as various types of corporate cloud services, it is possible to achieve positive changes in the implementation of educational and scientific activities, applying new forms and models of its organization, and achieve positive effect both on the results of training and on the development of scientific research, improving the level of their organization, increasing efficiency.

## Keywords

open science, open science systems, virtual teams, open science tools, higher education institutions

## 1. Introduction

The principles of openness pervade the research cycle at all stages and promote cooperation and exchange of results, leading to systemic changes in the theory and practice of scientific research implementation [1]. Cloud-oriented systems of open science appear as tools for supporting open research, with the help of which the activity of virtual learning/research teams is ensured [2]. Access is provided to a flexibly organized pool of electronic resources, specialized software supplied as a service, means of support and management of an educational/scientific project, services design, visualization and presentation of data, statistical processing of results, semantic and syntactic analysis of texts, etc.

In the modern information and educational space, cloud-oriented systems of open science are among the leading trends. These ICTs provide support for such innovative forms of organization as collaborative learning and research through shared access to the ICT environment and software for solving tasks [3]; adaptive cloud-oriented data processing systems [4], in particular, big data [5]; adaptive cloud-oriented learning and research platforms deployed based on educational institutions or their units [6]; scientific and educational information networks, platforms and infrastructures, in particular, the European Open Science Cloud (EOSC) [7]; cloud services and electronic resources for educational and scientific purposes that are available for use [8, 9].

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In connection with the pandemic situation and then the war in Ukraine, the contacts of teachers and students were severely limited [10]. This complicates the preparation of students who come to the university with weak knowledge, as well as the training of graduates and postgraduates due to the lack of contact with their teachers and supervisors. In the university, self-study is a typical activity process [11]. This creates good prerequisites for the integration of IT in learning in virtual online learning environments [12]. In practice, however, there is only general-purpose software and a lack of IT tools to create personalized learning environments and systems [13].

In this regard, the study of various tools for the formation of cloud-oriented virtual systems to support the processes of educational and scientific cooperation falls into the focus of the project's research "V4 Educational Academic Portal for Integrating IT into Education" (EDUPORT), which is carried out in 2022-2023 with the support of the Visegrad Foundation (Visegrad Fund, <https://www.visegradfund.org/>), and member of which are educational and scientific institutions of Slovakia, the Czech Republic, Poland, Hungary and Ukraine.

The relevance of the work is due to the need to increase the efficiency and effectiveness of the development of ICT competence of university teachers due to the broader use of tools and technologies of open science in the learning process, particularly with the use of cloud-oriented solutions. The introduction of cloud-oriented systems and services of open science is an essential prerequisite for improving the qualifications, training and retraining of educational personnel for active professional activity and self-realization in a high-tech society, the use of innovative methods and teaching tools, the implementation of innovative forms, methods and approaches to its organization.

### 1.1. Analysis of recent studies

The principles and conceptual foundations of open science are highlighted in international documents relating to the features of the formation of the European Research Area, and the concept of open science [14, 15, 16]. Scientific and methodological issues of creating and developing a cloud-oriented educational and scientific environment in the context of open science priorities are considered by Lytvynova [17], Bykov and Shyshkina [18]. The question of the formation and development of competencies of open science is highlighted by Schmidt et al. [19]. The problem of forming virtual systems of open science in educational institutions, introducing the principles of open science into teaching and research, and creating open educational and scientific environments requires further study.

Cloud tools have transformed the learning environment, enabling massive data processing, sharing and reusing research results, greater scalability of computing power, and service-oriented architecture [20]. This approach provides open, collaborative, project-oriented learning. The Institute for Digitalization of Education of the National Academy of Educational Sciences of Ukraine developed basic approaches to form open education models [21]. These research results form a theoretical and methodological foundation for further work in this direction; in particular, it is advisable to use them in the development of open science systems as a new stage in the implementation of open education along with the broad implementation and use of these approaches in all areas of the education system.

In [22] the important issues of open science such as mapping and visualization of scientific domains are considered. The ICT tools of open science such as Bibexel, Pajek, VOSViewer, programmes used for processing and visualization of bibliographic and bibliometric data are analysed. The implementation of these tools to support the activities within the framework of the IRNet research network project shows the relevant tendency.

The research methodology aims to implement the general principles of open science, such as open access, data, research methods, communication, and evaluation [16]. The cloud-oriented approaches deliver useful tools for this purpose. The main features of cloud computing are the flexibility and scalability of IT infrastructure, helping to achieve significantly higher efficiency in training within the cloud-based learning and research environment [18, 23].

The scientific and methodological study of the problems of forming a cloud-oriented educational and scientific environment needs further development in the context of the priorities of open science [18, 24]. In particular, in the aspect of using powerful platforms for storing and processing volumes of

scientific data, as well as flexible selection and scaling of computer capacities. Using cloud platforms in combination with communication services creates much more opportunities for the functioning of virtual scientific teams [25].

Summarizing the experience of using cloud-oriented tools of open science to support the processes of communication, joint work, adaptive content management, creation and use of electronic resources and services in the course of educational and scientific cooperation in virtual teams, it can be argued that it can be useful for further implementation in the domestic educational and scientific space, particularly in a university teacher education.

## 1.2. The research aim

The work examines the justification and development of the use of cloud-oriented systems of open science as one of the promising directions of supporting the activity of a virtual research team to conduct educational and scientific activities of team members.

## 2. The research results

In the information and educational environment, there are new models of the organization of educational activities, which are based on innovative technological solutions for the design of the environment, among which the hardware and software of adaptive information and communication networks, and cloud solutions play a significant role.

The issue of adapting and adjusting the tools and services of the information technology educational environment to the needs of users to maximally realize the pedagogical potential of using the most modern ICT, in particular, cloud-based, to achieve improvement in learning outcomes, as well as improvement of the process of scientific research activities of teachers, development of joint work skills, requires the introduction of innovative approaches. These approaches should provide the most appropriate ways of organizing access to educational software, in particular, based on cloud-oriented approaches that belong to the leading models of organizing the infrastructure of the educational environment and also become a catalyst for introducing innovative methods and approaches in educational practice.

In this regard, the study of various means and tools for the formation of cloud-oriented virtual systems of open science to support the processes of international scientific cooperation falls into the focus of research of the project “V4 Educational Academic Portal for Integrating IT into Education” (V4 EDUPORT), which is carried out in 2022-2023, and a participant of which, along with educational and scientific institutions of Slovakia, the Czech Republic, Poland and Hungary, was the Institute for Digitalization of Education of the National Academy of Educational Sciences of Ukraine, which represents Ukraine.

The V4 EDUPORT project aims to combine the knowledge gained in educational and scientific institutions of the V4 countries to create an educational portal, appropriate IT software and common infrastructure for creating educational packages and multilingual content for this portal in the blocks EDU-TUTOR, EDUPACKAGES and EDU-IT (part of EDUPORT will be publicly available, part available to partners).

The main result of the EDUPORT project was the creation of a cloud-oriented IT support system for research activities of a virtual scientific team. The system consists of network ICT infrastructure, educational software WPadV4 and PIKS channels – online application (PHP/MySQL) – and personal information and communication system of project participants.

The WPadV4 application software was installed on Windows virtual desktops for ten computers of researchers and project partners. Although this solution is quite simple since WPads can be created and used even by individuals with a low level of IT skills, solutions like this have not been considered before. This is because the WPad application, although a database application, was designed around a non-relational paradigm; the novelty of this decision is confirmed by the registration of utility model

8787 in the patent office [15]. As a result, knowledge modelling using WPad tables allows you to create educational and informational solutions to be applied in the teaching and research process.

WPad was developed as a personal IT support tool for research areas such as learning analytics, digital libraries, overcoming language barriers and computer-supported collaborated learning (CSCL). Although some CSCL issues can be addressed in terms of offline collaboration with students (e.g., students creating collaborative e-learning material to bridge knowledge gaps), this was also necessary to address in a study focused on the collaboration of an international teaching team.

It should be emphasized that WPad is special software that uses simple tables into which the teacher, researcher, and/or students manually, copy, or automatically paste educational content. The key point here is that unlike text-based computer files (.doc, .pdf), WPad tables only work with selected content required for lectures, exercises and self-study. Content is also stored in files (.dbf) that you can use to transfer information to other WPad files, send, store in the cloud, and create HTML files for eLearning.

Thus, the implementation of a simple solution is considered, which is based on an interdisciplinary approach and uses the universal author's software WPad for modelling the processes of knowledge management in education and research. The approach is based on the use of WPad tables, in which only specially selected educational content is inserted, while the most recent studies are characterized by the use of standard computer files with unselected content. Thus, there is an opportunity to achieve a higher pedagogical effect. Using this software, participants in the educational process can create, transfer and consume content faster. In addition, it is a cheap and convenient solution, since the basic version of WPad only requires Windows and an Internet connection. The presented system should not be considered as a competition to existing software but as an additional tool for the personal IT support of teachers and researchers.

The V4 EDUPORT project aims to combine the knowledge gained in educational and scientific institutions of the V4 countries to create an educational portal, appropriate IT software and shared infrastructure to create educational packages and multilingual content for this portal in the blocks EDU-TUTOR, EDUPACKAGES and EDU-IT (part of EDUPORT will be publicly available, part available to partners).

Processing of knowledge and context-controlled data tables is performed by the WPadV4 database application, authored by S. Svetsky [26]. Because this software is based on the abstraction of metadata and content, it allows users to process content in a default structure. Thus, the user can create tables of knowledge to build educational texts and material for lectures and exercises.

The principles and priorities of open science were followed by using a cloud-based learning and research platform to support collaborative processes. These included communication, information retrieval, data exploration, sharing of results and methods, and content management, as all required materials, such as instructional materials, articles, training materials, document collections, etc., are currently supported and available on the platform. Adaptive content management was supported by the research tool WPadV4, which was used to process available data based on a robust model. Thus, all data collected during the study was valid, accessible, compatible and reusable for all partners. It was supposed to ensure the openness and flexibility of scientific cooperation processes.

In particular, thanks to the involvement of cloud-oriented platforms in the educational process, and the deployment of various types of corporate cloud services on them, it is possible to create specialized environments that are mostly focused on solving certain types of problems. For this, there may be no ready-made publicly available services, while the corporate cloud-oriented environment can be adapted, configured and oriented to any type of task that arises in the practice of research. It provides the most expansive opportunities for creating unique authors' methods and organized systems for solving particular problems. It will make it possible to achieve positive changes in the implementation of teachers' educational and scientific activities, improve its qualitative and quantitative indicators, and introduce new forms and models of its organization. It is advisable to use such platforms as, for example, MS Azure, AWS or others [27, 28, 29, 30] to support the deployment of corporate cloud-oriented platforms. The experience of their use, in particular, in the project "V4 Educational Academic Portal for Integrating IT into Education", shows that it has a positive effect on both learning outcomes and the development of scientific research, improving the level of their organization, and increasing efficiency.

### 3. Conclusions and discussion

It has been established that thanks to the broader involvement of tools and services of cloud-oriented platforms as well as various types of corporate cloud services in the educational and scientific process of institutions of higher education, it is possible to achieve positive changes in the implementation of this activity, improvement of its qualitative and quantitative indicators. Application of new forms and models of learning and research activities has a positive effect on both the results of training and the development of scientific research, improving the level of their organization, and increasing efficiency.

The training component with WPadV4 software was developed and tested based on a cloud server deployed on AWS (Amazon Web Services). It paves the way for the development of methods for deploying educational and scientific components in the learning and research environment of higher education institutions.

The main result of the EDUPORT project was the creation of a cloud-oriented IT support system for research activities of a virtual research team. The system consists of network ICT infrastructure, educational software WPadV4, methods of creating educational packages and accompanying educational materials and their multilingual support, and PIKS channels – an online application (PHP/MySQL) developed to implement personal information and communication systems. It supposes the adjustment for the learning and research needs of the project team or the learning process. These tools may be useful to support scientific and educational information networks of open science; communications; joint work; adaptive content management; and creating and using electronic educational resources in the process of organizing educational and scientific cooperation in virtual teams. The question of the selection and integration of services, the study of their various components, and the most appropriate ways of application in open science systems, the combination of intelligent technologies and network cloud services is a perspective for further research.

The cloud-based approach is aimed at development of the systems that are open and flexible. Among its advantages is the possibility to transform and modify the educational environment if needed. That's why the selection and choice of useful learning and research tools need further investigation.

The European Open Science Cloud (EOSC) needs special attention in improving both the content and technological components of the systematic support of the teacher training process. It is a pan-European infrastructure that unites electronic resources and services developed within the framework of European research projects and not only them, classified according to scientific fields and types of activities. The toolkit posted on the EOSC portal is quite diverse, and the list of services is extensive. The portal provides clear instructions for registration, navigation, search for services, settings, and access. The methods of using the services of the European cloud of open science, in particular those developed in [24], in the educational and scientific process, require further development and implementation. It is necessary to provide support to teachers in implementing new practices.

Considering the existence of different models of using cloud services, it is worth paying attention to a balanced choice of the most appropriate solution suitable for each case, for a specific situation, both for a collective and an individual user. The choice of the SaaS model (software as a service) in this regard can be justified by the fact that these services are the most accessible. However, they require a thorough market analysis and a pedagogically balanced choice of a software application, with the help of which it would be possible to achieve the necessary educational or scientific goals. These tools can be used both in the activities of an individual teacher and in the individual or collective work of a project team.

The experience of using cloud-oriented open science tools to support international scientific cooperation in educational institutions is summarized: communication; joint work; adaptive content management; supporting the processes of creating and using electronic educational resources in organizing educational and scientific cooperation in virtual teams. It can be used to further develop open science systems in the national educational and scientific space.

The question of the selection and integration of services, the study of their various components, and the most appropriate ways of application in open science systems, the combination of intelligent technologies and network cloud services provides a perspective for the further development and implementation of open science approaches.

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