Smart systems of open science in teachers' education

Journal of Physics: Conference Series **2288** (2022) 012035 doi:10.1088/1742-6596/2288/1/012035

Smart systems of open science in teachers' education

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Abstract. The project announced by the authors is focused on the smart systems of open science, the issues of elaboration of methodological, methodic, and organizational support for the use of these emerging ICT in teaching and research, increasing the level of ICT competence of educators, including teachers. Given the significant pedagogical potential and novelty of existing approaches to the use of smart learning systems meaning first of all the cloud-based adaptive open science systems, their design and use in educational institutions, these issues still need theoretical and experimental research, refinement of approaches, models, methods and techniques, possible ways of implementation. In the process of studying leading experience, the following advantages of using the cloud-based services for teachers' training were identified: resource savings, access mobility, elasticity, and others. The cloud-based methodological system for educational personnel training at different levels was proposed and considered: for the training of students for the Master level for educational sciences; for the in-service teachers' training. The methods and tools of smart systems design and implementation were considered and evaluated. The recommendations and suggestions for the advisable ways for smart systems of open science introduction into the learning process were provided.

1. Statement of the problem

In the conditions of globalization, European integration, and accelerating digital transformation of many spheres of human activity there is a need to create a competitive educational sphere in Ukraine, formation of modern human competencies and qualifications, increase the level of accessibility and quality of education. According to SiS.net (a project within the framework of the European Union's Framework Program for Research and Innovation "Horizon 2020"), there is currently a shortage of science-oriented, "scientific-knowledgeable" people at all levels of society and the economy.

The key factor in training such people who are able to adapt to dynamic socio-economic changes, think critically, effectively solve professional and everyday problems with modern technological advances and digital solutions, engage in sustainable self-development, be successful in their profession, etc. is a cooperative effort of motivated, qualified educators.

In turn, one of the main conditions for improving the quality of educators' training, increasing the level of their professional competence, wider use of innovative pedagogical technologies, expanding the share of research approach in teaching is the introduction of the cloud-based open science systems that are smart learning systems of a new age in pedagogical and postgraduate pedagogical education. This requires substantiation of theoretical and methodological principles of creating cloud-based systems of open science in educational institutions, research of innovative

models, principles and methods of their formation and use, and determination of the most appropriate ways of implementation.

It is necessary to take into account global trends in the transition to the mass introduction of research and educational platforms and infrastructures of open science, in particular, the services of the European open science cloud (EOSC), which enables the creation of a new high-power information technology ecosystem in educational institutions. Solving the problems of the introduction of cloud-based systems of open science in educational institutions is an essential prerequisite for training specialists capable of appropriate, scientifically sound application of emerging ICT in their future educational and scientific activities. It determines updating the content and approaches to modern teachers' training, the formation of their readiness for professional activity in a continuous digitalization, in particular through the introduction of smart systems of open science.

1.1. Analysis of recent research

The problems of design and use of the cloud-based services and technologies of open science in educational institutions are among the top in the field of digitalization. Cloud-based open science systems of a new generation are the smart systems as they are more adaptive, flexible, powerful, and functional, thus attracting more and more attention from researchers. Their introduction should have a positive impact on the quality of education, providing wider access to promising ICT, expanding the share of research approaches in education, and improving the quality of educational services. Problems, tendencies, and prospective ways of introducing cloud technologies of open science in the educational process were considered in many works of foreign and Ukrainian authors.

V Yu Bykov and M P Shyshkina [1] studied the issues of using the cloud-based systems of open science within the university learning and research environment in the context of integration to European Research Area (ERA).

S Lytvynova, A Manako [2] and M Pikulyak [3] considered the features of adaptive learning systems use and their management.

The issues of the cloud-based learning and research environment design at the university was studied by a group of scientists V Yu Bykov, S M Vernygora, A M Hurzhii, L M Novohatko, O M Spirin and M P Shyshkina in [4].

Y Rosen, I Rushkin, R Rubin, L Munson, A Ang, G Weber, G Lopez and D Tingley in [5] and L Balme [6] paid attention to the different aspects of implementation of adaptive learning systems for learning and P Kerr [7] considered this type of systems in the aspect of teachers' training.

The concept of adaptation and adaptability, content, and stages of adaptive technologies was studied in the work of H Yelnykova and Z Ryabova [8].

The historical development of the paradigm of open science was studied by A Grand [9]. J Lodge, L Corrin, G-J Hwang and K Thompson [10] investigated the impact of open science on research educational technologies.

Various aspects of adaptability in learning were discussed in [11]. The use of adaptive tests was described in [12].

The series of adaptive learning systems have been considered in recent years in Ukrainian research for the prospects of their use in Ukrainian educational institutions [13]. Among them, there are such as Course Arc, Realizeit, Brightspace LeaP, Mobius, WileyPLUS, Knewton, and others. We also consider the comparative analysis and evaluation of these systems by the range of indicators, made by H B Varina, V V Osadchyi, K P Osadcha, S Shevchenko and S H Lytvynova [14]. We would like to draw attention to the adaptive learning platform Knewton (`https://www.knewton.com/`), as the promising one for the implementation of teachers' training. The effectiveness of the named platform is confirmed by empirical data

obtained by Arizona State University (USA) as a result of training over 2000 students. It was found that the share of students who completed the course increased (from 64% to 75%), with 45% of them completing earlier than planned. The share of non-graduates decreased from 16% to 7% [15].

Several adaptive learning aspects were discussed in the course of the Precalculus [4].

In recent years there is a tendency for the implementation of augmented reality (AR) and virtual reality (VR) technologies within the learning systems which also adds value to the adaptability o these systems [16]. VR training and assessment can have a progressive impact on productive learning [17].

Using VR / AR technologies diversify the educational process through teamwork [18].Adaptive technologies can also affect the interaction of participants in the learning process [19]. The adaptive systems that provide VR / AR technologies may be used to support the data processing [4].

Therefore, there is a need to train teachers and educational staff to implement smart systems and artificial intelligence [20].

To find out which learning platforms are used in Ukrainian institutions of pedagogical education, and whether there are adaptive ones, we conducted a survey where representatives of 31 Ukrainian institutions took part (16 pedagogical universities and 15 institutes of postgraduate pedagogical education), 2018-2019. Taking into account the adaptability indicators, we established that currently none of the surveyed Ukrainian institutions used adaptive platforms. Thus, 90% used Moodle LMS, 16% – Google Classroom, 7% – Office 365, 18% – other systems, and 7% – nothing.

We consider the following reasons why Ukrainian institutions of pedagogical education do not use adaptive systems:

- no localization, only English content and technical support;
- the potential for "bugs", failures, as adaptive platforms are difficult to implement, so to test them flawlessly is almost impossible;
- the cost which is rather high for certain individuals, including teachers. There are currently no free adaptive platforms (trial version only).

The purpose of the research is: to consider the concept of smart systems of open science in the context of teachers' education; to evaluate the state of the art on the problem of elaboration in Ukrainian and foreign educational spaces and to consider the possible methods, forms, and recommendations for educators on using smart systems of open science in personalized learning implementation.

2. The conceptual apparatus of research on smart systems in teacher education

Based on the analysis of research trends in education, key concepts of investigation and interpretations of the basic terms were defined.

The cloud-based learning and research platform is considered as a set of cloud-based tools for support of various training and research activities. Many different tools can be integrated within one platform, providing more opportunities for open and adaptive learning and research.

Particular attention should be paid to the formation and development of cloud-based systems, which may include a variety of services for learning and research and their combinations, which are divided into appropriate groups. Some scientists understand this concept as a system of specific cloud services. Another approach supposes that a separate cloud service acts as a cloud-based system. In this case, the cloud-based system may be considered a computer program for educational purposes, which is located in the cloud. That is, the concept of a cloud-based environment is rather broader. However, a cloud-based system is combined in such

an environment with other components according to the structure of the cloud-based learning support.

The cloud technologies which provide the background for the smart systems of open science possess such innovative features being intrinsic to the cloud computing systems as openness and flexibility [5]. If the goals and objectives of the learning environment change, it is possible to adequately change its tools, as well as the overall composition and structure, to modernize the methods of their use within the cloud-based setting.

Under *the cloud-oriented methodological system* we mean a system of learning methods of using cloud services or specially designed cloud-oriented components for educational and scientific purposes, combined into a single system based on formative factors, among which there are the cloud-oriented approach and the integrity of learning content.

A smart system of open science is a cloud-based system (based on a cloud platform), which can be automatically adjusted according to the goals and objectives of the process of scientific cooperation, various individual characteristics, and the educational and scientific needs of virtual research participants.

We also make attention to the peculiarities of the content meaning and differences between the concepts of big data, smart data, and fair data as important to the design of the smart systems of open science.

Big data are the vast data sets that are accumulated in organizations daily. Then by the smart data, we may consider the data that contains information about the target audience to be segmented form. The smart data available for processing by a human mind still may be produced based on big data. Artificial intelligence techniques are used to collect and provide these data to help humans deal with them. Thus, these data may be produced automatically and also may be collected and used by humans. On the contrary, the research data are also the kind of smart data but the humans usually collect these data consciously and in a planned manner due to the reasonable research aims. Still, the adaptive research tools for data processing may be a useful instrument to support this process.

By *FAIR data* the research data that is findable, accessible, interoperable, and reusable are usually considered. These data are the most valuable if the context of open science systems design. The special tools and services are used to provide smart data processing and this is important to consider these tools among the teachers' training courses.

As a result, the introduction of open science norms in Ukraine should lead to greater exchange, accountability, reproducibility, and reliability of scientific materials and affect the learning process as a whole. In the process of studying Ukrainian and foreign experience, the following advantages of using cloud services for mathematical purposes were identified: resource savings; access mobility; elasticity, and others. The introduction of cloud platforms and services in the educational process leads to the emergence and development of innovative forms of learning and research organization focused on joint educational activities, creating more opportunities for educational and research projects. Methods and approaches of open science have a significant impact on the educational process, in particular, on teachers' education.

3. Current research developments and implementation

One of the main conditions for improving the quality of training of educational and research personnel, increasing the level of their professional competence, wider use of innovative pedagogical technologies, expanding the share of investigative approaches in teaching and learning is the introduction of smart open science systems in educational universities and postgraduate education. In this regard, there is a need for fundamental research on the design and use of cloud-based methodological systems of open science in the educational process of higher education and the professional development of teachers. For this purpose in 2021, a planned research "Methodology of using cloud-based systems of open science in educational

institutions" (# 0121U107673), has been started in the Institute for Digitalisation of Education of the NAES of Ukraine devoted to the issues related to the digitalization of open science. In particular, it is planned to explore the conceptual apparatus, principles, methods, and approaches related to the use of cloud-based systems of open science in the training and professional development of teachers; identify the tools and services that are most appropriate to use in this process; substantiate and develop a model for the use of the cloud-based systems of open science in teaching and professional development of teachers; to develop the learning techniques based on the model and to check experimentally efficiency of their use.

The expected social effect of the project is to improve the quality of the educational process of higher educational and postgraduate institutions; the effectiveness of the cloud-based tools and services introduction, the rise of the level of digital competence of teachers, the wider use of open science services in the educational process. The research is devoted to the methodology of open science services implementation at different levels of teachers' education – at the institutions for teachers training and also at the pedagogical universities to train educational personnel. For this purpose, the special training courses and appropriate learning methods were elaborated and implemented at different levels.

The training course "Smart Technologies in Education" was developed for the students of the National University of Life and Environmental Sciences, specialty Information and Communication Technologies in Education, 011 Educational, Pedagogical Sciences, 01 Education / Pedagogy, 2020-2021 academic year. The module "Smart technologies of open science" was introduced within this course aimed at increasing the competencies of students in open science. The total number of students was 30. Before the start of the course, the measurements of participants' ICT competencies were accomplished, which included issues related to the use of open science technologies. Before entering the training course only 1 respondent out of the total number has comprehended the concepts of open science or open data. Instead, 23 students answered that they knew only a little about these concepts. After completing the course, the vast majority of students (75%) showed a high level of awareness of the concept of open science, and the ability to use these services, which indicated the growth of relevant ICT competencies.

The methods of using smart systems of open science in the training of future Masters of ICT in education were used to meet the educational and scientific needs of learners, and to increase the level of their ICT competence. In course of training, such methods as explanatory-illustrative, practical, partial search, problem-searching, and problem-heuristic were used. In general, the training was aimed at the practical application of services and technologies of open science, and the ability to apply them in educational and professional activities. Lectures, seminars, laboratory works, independent work, and individual and group educational projects were used as forms of learning. The learning tools included electronic resources and adaptive cloud services that can be used to support open science systems and tasks (Microsoft Office 365: Teams; Power BI; Microsoft Azure). Practical tasks were focused on creating educational projects "in the cloud", acquiring skills of presenting and processing data in a cloud-oriented environment (Microsoft Office 365), the use of adaptive data processing services (Power BI); creation and use of virtual machines to use the computing power of cloud servers (Microsoft Azure). The expected result was intended at increasing the level of organization of educational research and the ICT competence of learners.

That is, if students have low awareness of open science services, what about in-service teachers? It is possible that the problem still exists at the stage of training in educational institutions. But to draw valuable conclusions, it was necessary to survey a representative sample of teachers from all regions of Ukraine and students of pedagogical institutions of higher education. To approve the received results, to support the principles of open science, to clarify the current stage of cloud-based open science systems use the survey was conducted, a group for teachers "Open Science in Education" was created based on Google Group (e-

mail: open_science_ua@googlegroups.com, link to the group description: https://groups.google.com/g/open_science_ua/about). The group is open and currently has 469 members (covering all regions of Ukraine). Every day the group grows by attracting new members.

The survey found that the majority of teachers (80%) were unfamiliar with the concept of open science, and its principles and did not know what European Open Science Cloud (EOSC) was. All respondents (100%) answered that they use only open electronic resources to search for educational literature.

To provide the necessary teachers' training the distance learning course "Open Science Cloud Services for Educators" was developed. For the whole period of study, it involved: researchers – 1, pupils and students – 2, managers of educational institutions – 3, employees of the administration of education – 7, educators of secondary schools – 10, other employees at school - 29, teachers of institutions of higher education – 58, managers of educational institutions – 66, teachers of colleges and vocational schools – 72, teachers of general secondary school – 395. Total registered – 921; joined the course – 774; completed the course – 643.

To conduct the course, the methodology of using smart services of open science in teacher training was developed. It was aimed at teachers' training and their professional development, expanding access to free cloud services, and increasing the level of ICT competence. In the course of training, the next training methods were used: the practical work; the problem-based teaching; the partial search; the problem-solving, and the explanatory-illustrative. In general, the training was aimed at learning and training the practical application of the adaptive open science tools (some cloud services, including virtual reality services) of EOSC. Lectures, computer workshops, educational and training classes workshops, webinars, explanations, individual consultations, and distance learning courses were used as forms of education. The learning tools included the services of the European Open Science Cloud and a platform to support distance learning courses (such as Moodle or Google Classroom). Practical tasks were focused on services of joint data processing and services of joint work on educational projects; using the EOSC services; mastering the skills of working with specialized cloud services, including virtual reality services, as tools of open science. The expected result was intended at expanding access to cloud services to support learning, increasing the level of organization of the educational process, in particular, the research component, increasing the level of ICT competence of learners.

To clarify the state of formation of open science competencies and evaluate the effectiveness of the proposed methodology of teachers' training, the following ICT competence components were measured: the skills and experience of communication in their disciplinary area and beyond; the skills and experience in research data management, analysis/use/reuse, dissemination. Each component was considered separately and calculated by levels: high, sufficient, medium, and low. At the end of the course, the same indicators of the open science competencies formation were measured. Analyzing the obtained results, we can conclude that the percentage of a high level of skills and experience in research, management, analysis/use/reuse, and dissemination increased to 31%, and a sufficient level increased from 9% to 24%. At the same time, there is an increase in the number of course participants who have a sufficient level of skills and experience in their disciplinary community and beyond: from 38% to 41%.

4. Recommendations, suggestions

The introduction of smart systems of open science in educational institutions is an essential prerequisite for training specialists capable of appropriate, scientifically sound application of promising information and communication technologies in their future educational and scientific activities. The above necessitates updating the content and approaches to teachers' training, the formation of their readiness for qualitative professional activity in education digitalization, in particular through the introduction of smart systems of open science.

Thus, the structure and composition of the training courses may be reconciled with the

planned development goals and new challenges that may arise in the future. To do this, it is necessary to consider and implement the methodological cloud-based system, which includes some separate methods of using cloud-based components for educational purposes in the teachers' training.

Among the areas of smart systems of open science introduction for teachers' training, there are such as:

- To support individual and collaborative forms of learning activities in the classroom and also in the extra classroom using the services of the public cloud-based platforms for educational purposes, for example, Microsoft Office 365 (Microsoft Teams), G Suite for Education, FaceTime, Google Duo, Hangouts and other;
- To include the cloud services of open science, in particular, the services of European open science cloud into the process of teachers' training and professional development in educational universities and postgraduate training;
- To create the smart systems of open science in educational universities including facilities and services of scientific-educational information networks; cloud databases and data collections, cloud-based office software applications, specialized software training tools, as well as EOSC services;
- To introduce and implement specially designed and tested cloud-based methodological systems into the process of educational personnel training at different levels.

5. Conclusions

In the conditions of globalization, European integration, and accelerating digital transformation of many spheres of human activity there is a need to create a competitive educational sphere in Ukraine, formation of modern human competencies and qualifications, increase the level of accessibility and quality of education. One of the main conditions for improving the quality of training of pedagogical, scientific-pedagogical, scientific personnel, increasing the level of their professional competence, wider use of innovative pedagogical technologies, expanding the share of research approach in teaching is the introduction of smart open science systems in pedagogical and postgraduate pedagogical education.

As a consequence, the introduction of open science norms in Ukraine should lead to greater exchange, accountability, reproducibility, and reliability of scientific materials and affect the learning process as a whole. In the process of studying Ukrainian and foreign experience, the following advantages of using cloud services for mathematical purposes were identified: resource savings; access mobility; elasticity, and others.

The introduction of cloud platforms and services in the educational process leads to the emergence and development of forms of organization of education and research focused on joint educational activities, creating more opportunities for educational and research projects. Methods and approaches of open science have a significant impact on the educational process, in particular, teacher education. Prospects for further research are the study of tools and services for the formation of cloud-based open science systems in educational institutions, justification, and development of methodological system use of cloud-based open science systems in the educational process of higher pedagogical, postgraduate pedagogical education institutions, providing guidelines for teacher training.

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