Author's Refresher Course for Mathematics Teachers on the Use of Open Science Cloud Services

Dmytro E. Bobyliev[1] [a], Maiia V. Marienko[2] [b], Mariya P. Shyshkina[2] [c]
and Svitlana M. Hryshchenko[3] [d]

[1]*Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine*
[2]*Institute for Digitalisation of Education of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine*
[3]*National University of Fiscal Service of Ukraine, 31 Universytetska Str., Irpin, 08205, Ukraine*

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Abstract: Nowadays teachers need to learn how to use cloud-based technologies and systems to organize distance and blended learning. It is a single cloud-based platform that would ensure the organization of the learning process in the whole without using the third-party tools. The use of the European Open Science Cloud (EOSC) in the process of teachers' training may be useful as a possible platform that brings together more than 200 cloud services. The use of EOSC may help to support the interdisciplinary links. It is the appropriate instrument being helpful for teachers to support the organization of the process of blended and distance learning. The article presents the structure of the author's advanced training course for mathematics teachers "Cloud services of open science in the educational environment of a school". The content of advanced training course, its purpose, and the list of topics are described. It is indicated which competencies are to be improved after successful completion of this course. The given study is the initial stage of the multilevel research. The author's advanced training course for mathematics teachers "Cloud services of open science in the educational environment of a school" is an experimental introduction of the model of the cloud-oriented methodical system for training science and mathematics teachers to work in a scientific lyceum that was introduced and tested in the educational process of Kryvyi Rih State Pedagogical University.

1 INTRODUCTION

1.1 Problem Statement

In view of the approval of the Resolution of the Cabinet of Ministers of Ukraine 21.08.2019 No. 800 "Some issues of professional development of pedagogical and scientific and pedagogical staff" (Cabinet of Ministers of Ukraine, 2019) the teachers' training courses have undergone significant changes. In the speech of Mandzii (Mandzii, 2020) the main opportunities for professional development of teachers were revealed. The main changes in the professional development of teachers include the availability of free choice of seminars, training, workshops, webinars within the in-service training program. There are

[a] https://orcid.org/0000-0003-1807-4844
[b] https://orcid.org/0000-0002-8087-962X
[c] https://orcid.org/0000-0001-5569-2700
[d] https://orcid.org/0000-0003-4957-0904

several areas of teachers' training, but in this study we can single out the use of information and communication technologies and particulary the cloud-based in the educational process.

The content of teachers' training courses is also influenced by the situation connected with the introduction of quarantine measures in Ukraine related to the spread of COVID-19 (2020–2021), as the different forms of distance work, blended and distance learning have become widely used (Abdula et al., 2022; Kovalchuk et al., 2023; Kucher et al., 2022; Tkachuk et al., 2021). To organize distance and blended learning, teachers need to learn how to use the cloud-based training technologies and systems that ensure the organization of the learning process in the whole within the single platform without the use of third-party tools. The option is to use cloud services and cloud-based systems in the process of teachers' training.

On January 16, 2020, the Verkhovna Rada of Ukraine adopted the Law "About Full General Sec-

ondary Education" (Verkhovna Rada of Ukraine, 2020), according to which the grades 10-12 belong to a profile level, which also requires appropriate specific changes in the retraining of subject teachers. A separate issue is in changing the legal status of the school because the lyceum teachers should meet higher requirements than other ones. Therefore, the content of refresher courses needs to be revised, updated, and filled with modern digital technologies. In particular, the requirements for teachers who will work in lyceums (or scientific lyceums) are increasing, so in-service training courses should gain more academic and scientific components.

The principles of open science will help effectively bridge the gap between researchers and teachers. However, cloud-oriented services of open science have not yet gained widespread use in teaching and professional development of teachers. Underlying the understanding of open science is the concept that research should be reproducible and transparent, and also have long-term value through effective data storage and sharing. Using the principles of open science can be useful for training and professional development of teachers, for the formation of cloud-oriented systems of open science. Effective adoption of open science principles through data management, reproducible research, and stakeholder engagement in multimedia applications may enhance teacher learning. However, there are technical, sociocultural, and institutional challenges to embracing open science, including practical approaches to overcoming these obstacles in teacher training and in-service courses.

The participation of teachers and students in the process of scientific research is an important element in establishing new connections between science and teaching staff. Therefore, it is important to introduce open science, which can contribute to innovations taking into account the needs of teachers, lead to mutual learning and develop a scientific culture in the entire society as a whole. In particular, the introduction of cloud-oriented systems of open science into the process of teaching and professional development of teachers will lead to an increase in the level of distance and mixed learning organization in general secondary education institutions.

1.2 Literature Review

Kaplun (Kaplun, 2021) analyzes the meaning of the concept of "blended learning" and describes possible scenarios for its implementation for teachers' training (for this, the scientist provides a classification of models of blended learning). At the Department of Science Education of the Kharkiv Academy of Con-

tinuous Education, the content of advanced training courses for teachers of natural and mathematical disciplines includes the study of the specifics of blended learning and its features.

Yevtushenko (Yevtushenko, 2020) described the system of professional development of science and mathematics teachers in postgraduate education in Ukraine at the structural (national, regional (regional level), local (city/district/united territorial community level) levels. The author highlights the most promising trends in the development of in-service teachers' training: a balanced combination of traditional and distance technologies and methodological systems of training, improving accessibility of resources and personal orientation.

The study by Bozkurt (Bozkurt, 2021) is devoted to the analysis of the social science teacher training program in terms of skills development in the 21st century. The study showed that the program needs to be improved because teachers had a low level of competence of interaction in the digital environment.

Arslan et al. (Arslan et al., 2020) implemented and evaluated the author's program of advanced training of English teachers in non-formal educational institutions. The two-week online curriculum was designed to meet the professional needs of teachers and and also contained tests. The results of the study showed that the program had a significant impact on the knowledge and behavior of teachers. Although most were positive about the program, some teachers suggested conducting a full-time program and extending the duration of the training.

Kimav and Aydın (Kimav and Aydın, 2020) describes the project of a contextual program of teacher training for the use of Web 2.0 tools in EFL lessons. The participants were 122 English teachers who worked at the School of Foreign Languages of Anadolu University. Eight consecutive stages were followed in the curriculum. This project, according to researchers, can be proposed and developed for such institutions that want to increase the competence of their teachers to integrate technology into the educational process.

According to Vicente-Saez et al. (Vicente-Saez et al., 2020), open science approach has great potential for organizing training and creating new knowledge, accelerating the process of research and innovation to find solutions to societal challenges and it will help to increase the level of specialists' training in certain fields.

Scientists note that the practices of the "old school" – a lot of outdated scientific norms sometimes impair the reliability of research. Therefore, certain

norms and practices of "open science" have been developed for different scientific fields to solve these problems. This question was explored in (Gehlbach and Robinson, 2021) namely to what extent and how these norms should be adopted and adapted to pedagogical psychology and education in a broader sense.

In November 2018, the European Commission launched the European Open Science Cloud (EOSC) in Vienna. EOSC envisages the creation of a European data transmission infrastructure, the integration of high-capacity cloud solutions, and ultimately expanding the scope of these services to include the public sector and industry. The European Open Science Cloud (EOSC) initiative aims to support more than 1.7 million researchers and promote interdisciplinary research in Europe. To consider the research community needs, the EOSC Secretariat organizes seminars, interviews and consultations (Chambers et al., 2021). The purpose of such activities is not only to identify the real needs for research infrastructure services and policies in social sciences and humanities, but also the visions and future needs.

Understanding the structure of EOSC is the first step in recognizing the opportunities offered by the recently launched EOSC services. The study (Budroni et al., 2019) offers ideas for a better understanding of EOSC implementation at the present stage.

Higher education is an environment where open science and open education can be linked within a general concept of openness. Open-source research tools are easy and accessible to use for teaching and learning and to access research data and resources by students (Heck et al., 2020).

The purpose of the study is to describe and sustantiate the results of development and implementation of the author's course for advanced training of mathematics teachers "Cloud services of open science in the educational environment of a school".

2 RESULTS

Due to the transition to new standards, there is a need to retrain mathematics teachers. In the coming years, several problems related to mathematics education will have to be solved, among them there are such as:

1) the modification of the content and change of some methodical features of teaching mathematics in secondary and specialized school in particular:

  - the preparation for the implementation of educational standards of the new generation during the teaching of mathematics;

  - the formation and development of mathematics educational competencies;
  - the introduction of modern educational technologies in teaching mathematics;
  - the strengthening of applied and practical orientation in teaching mathematics;
  - the analysis and adaptation of the logical and general cultural components of mathematical training of teachers to modern requirements;
  - the improving the system of working with learners who show interest and ability to study mathematics;

2) the use of modern information and communication technologies (ICT) in teaching mathematics at school:

  - the methodological aspects of using interactive whiteboards in teaching mathematics;
  - the use of Internet resources in education;
  - the analysis of ICT capabilities in distance learning of mathematics;
  - the mathematical packages and training programs in mathematics;
  - the development of media resources and experience of their application in teaching mathematics;

3) the formation of quality assurance system of science education due to the new standards:

  - the modern means of assessing the results of teaching mathematics;
  - the monitoring, measuring, and analyzing the quality of mathematical training of learners;
  - the information technologies in quality assurance systems of science education.

The formulated topical problems of mathematics education in a modern school served as a basis for compiling the program of the author's course of professional development of mathematics teachers based on Kryvyi Rih State Pedagogical University (6 hours).

In 2019, the experiment "Designing a cloud-oriented methodological system for training teachers of science and mathematics to work in a scientific lyceum" was launched. Research work is carried out based on 6 institutions of higher education, among them there is the Kryvyi Rih State Pedagogical University. The author's advanced training course for mathematics teachers "Cloud services of open science in the educational environment of a school" is an experimental introduction of the model of the cloud-oriented methodical system of training science and mathematics teachers and mathematics to work in a

scientific lyceum in the educational process of Kryvyi Rih State Pedagogical University.

The main purpose of the refresher course implementation is to form the theoretical foundations and practical techniques necessary for teachers professional activity due to the new standards.

The goal is achieved by mastering the concept of open science, the principles of open science and its significance for a teacher of mathematics; the practical mastering of skills of work with an open science platform, the application of its tools (the separate components) by mathematics teachers; the creation of own project and its filling it cloud services of open science.

The objectives of the refresher course application. The task of the refresher course introduction for teachers of mathematics is to master the theoretical foundations of open science, awareness of the need to use cloud-based systems and cloud services of open science in education; the formation of knowledge about the forms, methods, and approaches to the use of the open science platform and its components for the organization and maintenance of educational activities; gaining practical skills in using the open science platform, in particular the services of the European Open Science Cloud by teachers of mathematics.

The direction of study: the use of information and communication (digital) technologies in the educational process, including e-learning, information and cyber security.

The scope: 0.2 ECTS credits, 6 hours.

The distribution of hours: classroom work, 6 hours.

Persons carrying out the program: mathematics teachers of general secondary education institutions of any qualification category.

A certificate about advanced training of the appropriate standard is issued based on the results of successful training under the program.

The teaching methods are: the practical; the problem-based teaching; the research; the partial search; the problem-searching; the explanatory-illustrative.

The forms of study are: the practical; the problem-based teaching; the research; the partial search; the problem searching; the explanatory-illustrative.

The teaching tools are: European Open Science Cloud (EOSC) tools (separate cloud services) and a platform (or system) for organizing and conducting distance learning courses (e.g. Moodle or Google Classroom).

The requirements for hardware and software on the user's computer are: up to 1000 learners can simultaneously work with the tools (separate cloud services) of the European cloud of open science, which are available through a browser; the workplace must be equipped with a computer (laptop, netbook, tablet), possibly using a smartphone.

The prerequisite: an Internet connectivity (wired, mobile, or Wi-Fi).

While mastering the advanced training course the mathematics teachers learn to use modern digital technologies, with the focus on the introduction of cloud services to the organization of the educational process, the implementation of individual and group projects, the organization of distance and blended learning.

Here is the content of the author's refresher course (table 1). In the process of teaching mathematics, teachers develop spatial imagination, develop the ability to think logically, operate with abstract objects and correctly use mathematical concepts and laws to build a mathematical model of a situation, to understand the beauty of mathematical reasoning, to cultivate determination, perseverance.

However, today not only mathematical but also ICT competencies of teachers related to teaching mathematics play an important role. The world is becoming more dependent on information technology, and both learners and teachers must have a fairly high level of relevant competence. The program of the refresher course includes lectures and laboratory work of learners on ICT. There are some topics examples.

Topic 1. The concept of open science and its significance for the teacher of mathematics (the lecture).

Topic 2. Open science platform and its components (the workshop).

When working according to the new standards, the problem of identifying, supporting and developing talented young people, their specific training and education aimed at training future highly qualified specialists remains relevant. During the course, the issues related to the olympiads of students of different levels were analyzed; the goals, objectives of the olympiads; the methods of training students were analyzed.

Here are the main issues of the methodological section of the course program.

Topic 1. The concept of open science and its significance for the teacher of mathematics (the lecture).

The basic concepts. The fundamentals of open science. The concept of open science. The principles of open science. The fundamentals of academic integrity for teachers and students. The importance of open science for mathematics teachers in the learning process at the profile level.

Table 1: The structure of the author's refresher course.

No.	Topic	The form of the training session	The duration of the lesson
1.	The concept of open science and its significance for the teacher of mathematics	lecture	2
2.	Open science platform and its components	workshop	4
	Total:		6

Topic 2. The open science platform and its components (the workshop).

The pequliarities of using the European Open Science Cloud (EOSC). The main features of the open science platform and the difference from EOSC. The stages of registration and project creation in EOSC. The main classification and categories of cloud services of open science. The selection of open science cloud services for use in the educational process. A brief overview of specialized cloud services of open science. There is an exchange of experience in the use of ICT in mathematics lessons between learners. The list of competencies to be improved is the next:

1. The ability to monitor pedagogical activities and identify individual professional needs.

2. The ability to determine the conditions and resources of professional development throughout life.

3. The ability to search for scientific and methodological materials in open journal systems.

4. The ability to select and use open source cloud services to achieve this goal.

5. The ability to organize and implement the learning process using the European Open Science Cloud and to effectively use open science cloud services.

6. The ability to establish cooperation within the open science platform.

The expected learning outcomes:

1. Knowledge and understanding of the role of cloud services of open science in the educational environment of the school.

2. The ability to use cloud services of open science in the educational environment of higher education.

3. The ability to analyze and select a cloud service of open science to achieve educational goals.

4. The knowledge and understanding of the basic concepts of open science, the principles of open science.

The teaching methods

1. The methods of organization and implementation of educational and cognitive activities:

   (a) According to the source of information:
   - Verbal: lecture (traditional or problematic), explanation.
   - Visual: observation, illustration, demonstration.
   - Practical: exercises.

   (b) According to the degree of management of educational activities:
   - under the guidance of a teacher;
   - performance of practical tasks.

2. The methods of stimulating interest in learning and motivating educational and cognitive activities:
   - educational discussions,
   - situations of cognitive novelty.

The control methods

1. The methods of oral control:
   - frontal survey,
   - interview.

2. The methods of self-control:
   - self-analysis.

The methodical support

- lecture outline;
- supporting presentations;
- methodical and training manuals;
- methodical recommendations;
- digital resources;
- professional development program.

The presented author's course is one of the components in the model of the cloud-oriented methodical system of preparation of teachers of natural and mathematical subjects for work in the scientific lyceum (Marienko, 2021). It can be offered as part of the implementation of this methodical system. The block of the methodical system unites three levels of implementation, each of which is a separate technique. The block of the methodical system of preparation

of teachers of natural and mathematical subjects for work in a scientific lyceum is the key one. However, its components include three main blocks, the introduction of a methodological system of training teachers of science and mathematics to work in the scientific lyceum at: the basic, the intermediate, and the advanced levels. The described author's refresher course is the intermediate level. This level involves not only a survey of existing cloud services but at least their groups, simultaneously used for different activities (Marienko, 2021).

Formalized interviews with learners (math teachers) were conducted at the beginning and at the end of the course. The interview showed which active and interactive methods were used by teachers in the learning process and for what purpose they were used:

1. What active and interactive methods do you use?

2. How often do you use them?

3. Explain and justify the technology of use.

During a survey conducted in a form of the formalized conversation and interview at the beginning of the training, it was found that:

1. The use of some elements of the strategy of the open science introduction and the teaching techniques of its realization in the learning process: 52% – yes, 48% – no; including pair and group works: 62% – yes, 38% – no;

2. The comprehensive use of the strategy and techniques in the classroom in the presentation of educational material: 48% – yes, 52% – no;

3. The independent work on educational material, to use the strategy and techniques in the classroom: 33% – yes, 67% – no.

Also, at the beginning of the refresher course, a group of mathematics teachers (17 respondents) was interviewed to develop learners' research skills (figure 1). Learners of the refresher course believe that one of the best ways is to use a selection of creative tasks (14 respondents answered). Only 9 teachers out of 17 surveyed work with learners in electives and consider this path not very effective. For some reason, only 4 teachers believe that more complex tasks will help develop students' research skills.

Some questions concerned previous knowledge on the subject of the refresher course (figure 2). The total number of respondents in this survey was 19 learners of the refresher course. It turned out that before taking the refresher course, most respondents (16 teachers out of 19 respondents) were not familiar with the concept of open science, its principles and did not know what European Open Science Cloud (EOSC) was. At the same time, all respondents answered that they use
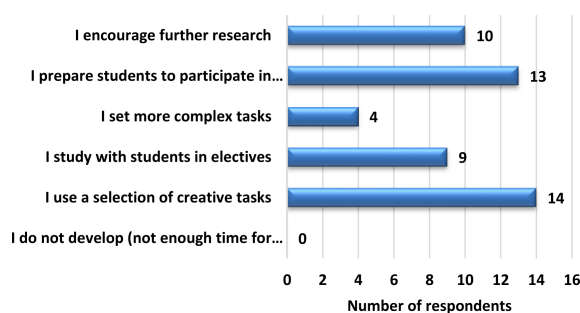

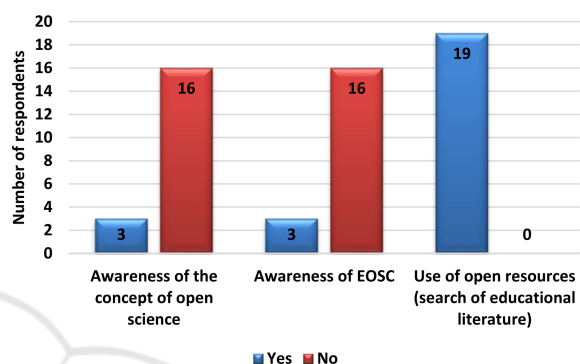Figure 1: Ways to develop students' research skills.

Figure 2: Preliminary awareness of learners on the subject of open science.

only open electronic resources to search for educational literature (figure 2).

A survey conducted at the end of the training in a form of the formalized conversation and interview showed the results presented in table 2.

Questionnaires of learners (mathematics teachers) showed their great interest in using interactive learning technology in advanced training courses. It turned out that learners:

1) approve the assistance and recommendations proposed for teachers of mathematics within the advanced training courses – 68%, difficult to answer – 20%, do not approve – 12%;

2) the level of use of the learning course electronic manuals contained in the LMS of Kryvyi Rih State Pedagogical University in the process of conducting the advanced training courses in mathematics is – 75%, can not use -12%, do not want to use – 13%;

3) the level of the use of the technologies described in the manual in LMS of Kryvyi Rih State Pedagogical University for their developments in mathematics are – 41%, can not use – 44%, do not want to use – 15%;

4) the ability to work independently on the material on the subject – 37%, can not work independently – 42%, do not want to work independently – 21%;

Table 2: Conducting a formalized interview and interview at the end of the course.

	Yes	No
used some elements and techniques in the classroom in the presentation of educational material	65%	35%
including pair and group works	77%	23%
comprehensive use of techniques in the classroom when teaching educational material	58%	42%
used independent work on educational material, to use strategy and techniques in the classroom	38%	62%

5) the ability to use of the cloud technologies of open science in preparation for presentations – 45%, can not use – 34%; do not use – 21%;

6) the desire to master the technologies described in the course manual in LMS of Kryvyi Rih State Pedagogical University for further professional activity – 90%, difficult to answer – 8%, do not want – 2%;

7) the ability to use the technologies described in the course manual in mathematics lessons in secondary education institutions – 80%, do not have a hard time answering – 12%, do not want – 8%.

Two months later after the course, a selective survey of students that have been taught by teachers was conducted. Students highly appresiated the advantages of open science technology in teaching mathematics used by mathematics teachers (that they acquired after passing the refresher course): 65% say that the favorable atmosphere for investigative learning and research has increased, 20% say that in such an atmosphere will be able to learn and investigate independently and only 15% are not sure efficiency. Students' interest in learning mathematics is more than 55%. Students claim that active and interactive technologies of open science help them to study mathematics (52%), to find the right direction in teaching mathematics (29%). And only 19% of students say that it does not affect their learning. More than 65% of students believe that math teachers make little use of active and interactive technologies of open science in the learning process (figure 3).

The last stage of the course was a round table

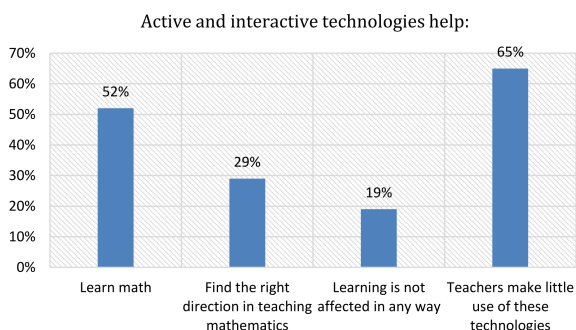Active and interactive technologies help:

Figure 3: Feedback from students on the use of interactive technology to technologies mathematics.

for learners and teachers. During the round table the most successful aspects of the retraining course were highlighted, the learners expressed their wishes to improve the program of future courses. In particular, it was proposed to increase the time for the analysis of the peculiarities of the development of Internet pages and sites of mathematics teachers, to consider the practical implementation of the technology of system-activity approach in mathematics lessons. In general, both teachers and learners of the course conducted the work was considered successful and useful for the practical activities of a mathematics teacher.

3 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The author's course of advanced training of mathematics teachers "Cloud services of open science in the educational environment of a school" is an experimental introduction of the model of the cloud-oriented methodical system of preparation of teachers of natural and mathematical subjects to work in scientific lyceum in Kryvyi Rih State Pedagogical University. The competencies of open science for learners of the advanced training course of Kryvyi Rih State Pedagogical University are constantly monitored. Due to the determined level, timely adjustment of methodical work and further planning for raising the professional competency of course learners is carried out. All participants in the experiment are provided with access to a cloud-oriented methodological system of training science teachers and mathematics to work in a scientific lyceum.

The introduction of the author's advanced training course for mathematics teachers "Cloud services of open science in the educational environment of a school" will lead to a partial solution to the problems associated with mathematics education. First of all, it concerns the modification of the content and changes in some methodological features of teaching mathematics in secondary and specialized schools. The main issues of the methodological section of the course program, aimed at individual competencies to be improved are the next:

1. The ability to monitor pedagogical activities and identify individual professional needs.

2. The ability to determine the conditions and resources of professional development throughout life.

3. The ability to search for scientific and methodological materials in open journal systems.

4. The ability to select and use open source cloud services to achieve this goal.

5. The ability to organize and implement the learning process using the European Open Science Cloud and to effectively use open science cloud services.

6. The ability to establish cooperation within the open science platform.

Questionnaires of learners (teachers of mathematics) showed their great interest in the use of interactive learning technology in advanced training courses. Two months later, a survey of students taught by teachers after the course was conducted. The students highly appreciated the use of interactive technology in teaching mathematics by mathematics teachers after taking a refresher course.

The study involved a small sample of respondents. Further research will be expanded and the sample of respondents will be increased. Subsequent research will deepen the study of the problem of teachers using open science services. As further researches discussion of problems of effective use of a cloud-oriented methodical system of preparation of teachers of natural and mathematical subjects for work in a scientific lyceum, including electronic educational resources, cloud services, etc.

As part of the author's refresher course, teachers only got acquainted with some EOSC services. The number of hours allocated for the workshop is not enough to study each individual EOSC tool in detail. Prospects for further research will expand the content of the author's course and focus on the use of individual services.

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