

Designing a cloud-oriented methodological system for training science and mathematics teachers in scientific lyceums

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Abstract

This paper presents an analysis of the results of a pedagogical experiment on designing a cloud-oriented methodological system for training teachers of natural and mathematical subjects to work in a scientific lyceum. Our review of recent research reveals that while the problem of reforming teacher training has been well studied, there is currently no cloud-based system specifically designed to prepare science and mathematics teachers to work in a scientific lyceum. Our survey of teachers' use of open science services, readiness to conduct research, and awareness of the functions and requirements of scientific lyceums indicates a need for such a system. We conclude that further development and implementation of a cloud-based methodological system that supports the integration of open science systems and services into teacher training and education is necessary.

Keywords

cloud-oriented methodological system, teacher training, natural and mathematical subjects, scientific lyceum, open science services

1. Introduction

In today's rapidly evolving technological landscape, science and mathematics teachers are expected to possess not only subject mastery but also the ability to effectively teach and engage students using modern tools and techniques [1, 2]. This requires a commitment to lifelong learning and a willingness to embrace new information technologies to enhance the delivery of educational content [3, 4].

In 2020, the COVID-19 pandemic necessitated the widespread adoption of distance learning technologies in Ukraine, as mandated by the Cabinet of Ministers of Ukraine and the Ministry of Education and Science of Ukraine. This highlighted the need for teachers to be prepared to organize and implement effective distance learning for their students [5, 6, 7].

The use of cloud services in education offers numerous advantages, including resource savings, collaborative online work, flexible access from any device or location, and the ability to organize distance learning [8, 9, 10, 11, 12]. However, the integration of cloud-based open

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science systems into teacher training remains an underexplored area that warrants further investigation.

1.1. Literature overview

The system of forms of teacher training in accordance with the requirements of the New Ukrainian School were described by Marchenko [13]. It was identified that the basis of modern teachers' training courses is the development of creativity, creativity, professional abilities and skills. The cloud technologies are briefly reviewed as a means to be familiar with certain topics of the subject area and perform individual practical tasks.

Krutova [14] studied the problem of using information and communication technologies in the system of professional development of teachers. Krutova [14], in particular, provides a list of Ukrainian and foreign platforms (distance learning courses) for teacher training.

Yevtushenko [15] identified the goals and objectives of advanced training of teachers of natural sciences and mathematics in terms of reforming education in Ukraine. In another study Yevtushenko [16] examines the problem of teachers' information culture, which he considers as the ability to perceive and learn something new.

Shyshkina [17], studied the problem of designing a cloud-based educational and scientific environment of higher education. The main problem outlined by Shyshkina [17] are: the considering of methodological principles of creation and development of educational and scientific environment of higher education institution based on cloud technologies, determination of criteria for its formation and evaluation.

The research by Lytvynova [18] is devoted to the cloud-based learning environments as a tool for solving problems related to the learning mobility of all participants in the learning process. Vakaliuk [19] defines the meaning of the concept of "cloud-based learning environment for bachelors of computer science" and provides a description of the structural model of cloud-based learning environment for bachelors of computer science.

Kuzminska [20] researched theoretical and methodical bases of designing and application of digital educational environment of scientific communication of masters-researchers.

Mayer [21] studied the problems of open science, e.g, the terminological apparatus and areas of use of open science.

Marilyn and Edrick [22] considered using the Science-Forums.net platform for scientific collaboration.

Researchers have considered the problem of teachers' training in accordance with the basic provisions of the New Ukrainian School Conception and put forward the idea that the program of teachers' training courses should include the study of cloud technologies. However, this is not a comprehensive study for the further use of the system of cloud services that will help teachers in preparing for work in the scientific lyceum. There are also some studies on the use of ICT in the educational process, the features of ICT and their shortcomings. However, the problem is very widely disclosed, it is not specified and is not focused on a specific target group. Also, some studies have considered the issue of updating advanced training courses for teachers of natural sciences and mathematics in connection with the reform of education in Ukraine.

Scientists have sufficiently considered various models of organization of the educational process using information and communication technologies (ICT). In addition, scientists have

developed models of cloud-based environment, in particular for the training of relevant profiles. However, the problem of designing a cloud-oriented methodological system for preparing teachers of science and mathematics to work in a scientific lyceum remains insufficiently studied.

The current state of preparation of teachers of natural sciences and mathematics for work in the scientific lyceum requires additional research and analysis. In particular, the skills of the use of the relevant ICT tools or cloud services at each stage of research should be considered. These prerequisites caused the need to launch a scientific and pedagogical experiment “Designing a cloud-oriented methodological system for training teachers of science and mathematics to work in a scientific lyceum” in 2019.

1.2. Research objective

The main objective of this research is to analyze and interpret the results of the ascertaining stage of a pedagogical experiment on designing a cloud-oriented methodological system for training teachers of natural and mathematical subjects to work in a scientific lyceum. The goal is to assess the readiness of Ukrainian teachers to use cloud-based open science systems in their educational practice. This will provide valuable insights into the current state of teacher training and the potential for integrating cloud-based technologies into the educational process.

2. Method

In a previous study [23] outlines the term “adaptive cloud-based system of open science”: “it is a cloud-based system (based on a cloud platform), which in its parameters can be automatically adjusted by the goals and objectives of the scientific cooperation process, different individual features and educational and scientific needs of the participants of the virtual research team” [23]. Since this study is not about adaptability, we can say that the technology of cloud-based systems of open science means purposeful, specially organized sets of information processes using cloud-based systems that meet all the principles of open science.

The pedagogical experiment on “Designing a cloud-oriented methodological system for training teachers of natural sciences and mathematics to work in a scientific lyceum” was launched in 2019 as part of the planned research “Adaptive cloud-based system of training and professional development of teachers of general secondary education” (DR No. 0118U003161, 20182020), conducted at the Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine. Research work is carried out on the basis of 6 institutions of higher education of Kherson State University, Kryvyi Rih State Pedagogical University, Ternopil Volodymyr Hnatiuk National Pedagogical University, Rivne Regional Institute of Postgraduate Pedagogical Education, Bogdan Khmelnytsky Melitopol State Pedagogical University and Zhytomyr Polytechnic State University. Experimental work on the design and use of a cloud-based system of training and professional development of teachers of scientific lyceums is planned as a natural, cross-pedagogical experiment, which consists of the following stages: preparatory and research. Thus, the research stage is divided into: ascertaining, forming and control.

The *purpose* of the experiment is to design and verify experimentally the cloud-based methodological system of training teachers of natural sciences and mathematics to work in a scientific

lyceum.

The use of cloud technologies and cloud services in the educational process is a promising trend of modern Ukrainian and foreign research. The methodological principles of the cloud-based learning and research environment design are well investigated by the Ukrainian scientists in the recent years [19, 18, 17]. At the same time, the cloud services are purposefully used both the educational process of institutions of higher education and general secondary education institutions. Cloud-oriented learning environments have some advantages for educational institutions in the organization of the educational process and the use of learning technologies.

The cloud-based system can provide services such as remote access to learning tools for higher education institutions to save on local and public funding in a cost-effective way. Students can access classes on a laptop, tablet, or phone from anywhere and use them freely. At the same time, the student can ask and answer questions and share what has been learned to help others. Access to analysis and user data means that such a system can be adapted to ensure maximum efficiency for both users and the education system. But most importantly, it helps young people access to access to learning anywhere, anytime, from any experienced teacher.

It turns out that most teachers of pedagogical schools are familiar with cloud services and express their intention to use cloud-based systems in the educational process. It was found that teachers who use a particular cloud service in the learning process fully involve all its possible tools. However, due to the lack of methodological developments, the use of cloud-oriented systems calls into question the effectiveness of their pedagogical use.

The purpose of the *ascertaining stage* of the pedagogical experiment is: to find out the current state of use of services by teachers of natural and mathematical subjects during the preparation of educational materials; to find out the readiness of teachers to perform personally and teach students to conduct research; to determine the state of awareness of teachers about the functions and requirements in scientific lyceums.

At the ascertaining stage, the experimental work was conducted in cooperation with Rivne Regional Institute of Postgraduate Pedagogical Education (2019) and Zhytomyr Polytechnic State University (2020). The following methods were used: questionnaires, interviews and observations. At the stage when the experimental sites were identified, two questionnaires were developed for each institution separately. The primary quantitative analysis of the experimental data is provided and the obtained results are summarized by means of distribution diagrams, tables and their interpretation is fulfilled. The quantitative analysis is to describe the current state of this problem. The reliability of the results is confirmed by the involvement of teachers from all regions of Ukraine.

3. Results

3.1. Rivne Regional Institute of Postgraduate Pedagogical Education

The questionnaire, developed for students of two groups of mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education, consisted of 13 closed questions (2 dichotomous and 11 alternative multivariate) and one open, short. At the beginning of the questionnaire, the respondent indicates in which city he / she works (teachers were from

different cities of Rivne region, in order to determine the territorial distribution) and his / her educational institution. The next point is to indicate which subjects the respondent reads, because at school a mathematics teacher can additionally teach other subjects. Thus, out of 45 respondents, not only mathematics teachers, but also 2 methodologists and 4 teachers were among the respondents. The aim was to find out the knowledge of mathematics teachers about the basic provisions and conditions of work in the scientific lyceum, how much teachers are interested in conducting research (one of the main requirements of work in the scientific lyceum) and involving students in research.

One of the key questions was to determine whether respondents understand how important is it for a science high school teacher to be engaged into research, as this is a basic requirement. It was found that the majority of teachers (43 respondents out of 45 respondents, which is 96%) believe that a teacher of a science lyceum should be engaged in scientific activities. At the same time, teachers who took part in the survey, in particular, submit articles to professional publications in Ukraine only for certification – 34 respondents (76%).

Only 10 teachers (22%) submit an article to a professional publication at least once a year. This is evidence that teachers are reluctant to publish their own research or do not have enough time to do so. Another possible reason is that teachers underestimate the necessary to be engaged in scientific research. These reasons were established during the interviews and clarification of certain issues related to the survey.

In the content of the cloud-oriented methodological system of training teachers of natural and mathematical subjects to work in the scientific lyceum there is a need to use English-language resources and services (specialized and general purpose). Therefore, the goal was to determine whether teachers were able to use English-language resources (not necessarily cloud-based). However, the results were not comforting enough: 35 respondents (78%) do not use any English-language resources or services. This is the evidence that in order to test and further implement a cloud-based methodological system of training teachers of science and mathematics to work in the scientific lyceum should develop detailed organizational instructions using certain tools and services (including English).

If the teacher uses only printed resources in English, some research may be needed to determine the level of skills in using cloud services. During the interview, it was found that teachers want to work with English-language services, however, they first need to master the skills of working with an online translator or installing plug-ins and applications to speed up the work and make it more comfortable. Such preparatory moments will not distract from the learning process and save time and effort (the teacher does not need to translate each menu or button with a printed dictionary, because, unfortunately, there are such situations). In order to find out the skills and abilities of conducting research work, the respondents answered the following questions: research of the state of the scientific problem, participation in scientific activity and implementation of the obtained research results.

A rather interesting result was that respondents are familiar with open science services (21 people, which is 47%). 22 respondents (49%) answered that they rely on their own experience to formulate and study the state of a scientific problem, but this is not enough, because in this case the scientific problem will not be fully investigated. Questionnaire answer options were designed to cover every aspect of the problem and to consider as many possible life options as possible.

The most common ways for teachers to participate in scientific activities were: participation in conferences (24 respondents, 53%) and individual scientific activities (21 respondents, 47%). Perhaps this will be enough for the secondary school (at least participation in conferences), however, if a teacher plans to work in a scientific lyceum, then cooperation with higher education institutions and project activities will play a significant role. Individual scientific activity, without combination with other ways of participation in scientific activity, will generally give a rather weak result, because in this case there are no discussions, exchange of experience and constructive criticism (discussion of existing methods, establishing new connections).

Among the ways of implementation and use of the obtained research results the most common are: publication of methodical materials (selected by 22 respondents, 49%) and self-implementation (selected by 19 respondents, 42%).

At the same time, self-implementation is not a very effective way, because one teacher will not be able to cover a geographically large enough number of participants. Therefore, this implementation will be local and available only to a narrow circle of participants (especially if the teacher does not sufficiently publish the results of their work, showing previous survey results).

3.2. Zhytomyr Polytechnic State University

The questionnaire “Skills of working with cloud services”, developed for four groups of students of the distance course of educators on the basis of Zhytomyr Polytechnic State University, consisted of 13 closed questions (3 dichotomous and 10 alternative multivariate) and one open, short. Some questions of the questionnaire are duplicated with those that were in the questionnaire for mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education. As in the previous survey, the respondent indicates in which city he works (educators from all regions of Ukraine took part in the survey) and his educational institution. Mandatory field to fill in – it is necessary to indicate which subjects the respondent reads (it was necessary to cover not only mathematics teachers, as the target group is teachers of natural sciences and mathematics). Thus, among the 824 respondents surveyed were teachers of computer science, mathematics, Ukrainian language and literature, English, history, biology, physics, foreign literature, geography, chemistry.

If you analyze the questions that are present in both questionnaires, you can trace certain patterns. The majority of respondents (789 people) believe that a teacher of a scientific lyceum should be engaged in scientific activity (95.8%). If we evaluate the use of English-language resources (services) by teachers, we can say that 66.9% (551 respondents) do not use, 31.8% (262 respondents) use such resources and 1.3% (11 people) use only printed English resources.

One of the main issues during the ascertaining stage of the pedagogical experiment is to determine the most common services among teachers that they use in preparation for the lesson. This issue is extremely important, because for the further implementation of a cloud-based methodological system, you need to have at least basic knowledge for the use of cloud services and their principles of operation. As can be seen from the results of the survey, only 548 respondents use cloud services in preparation for the lesson (66.5%). 574 (69.7%) – still used a local ICT tools. That is, teachers can not even assess the benefits of cloud services and their use in organizing group work of students.

The next stage of research was to assess the skills and abilities of teachers to use individual resources and services at different stages of research. After all, if the teacher has sufficient skills to work with services, he will later be able to teach this and his students by offering them as an alternative, such as spreadsheets. What resources are used by teachers to search for scientific (educational and methodological) literature are shown in Fig. 1. Among the answer options, the most common services were chosen, those that are available to teachers. Also, the list included open science services, as they can act as separate components of the cloud-oriented methodological system of training teachers of natural sciences and mathematics to work in the scientific lyceum.

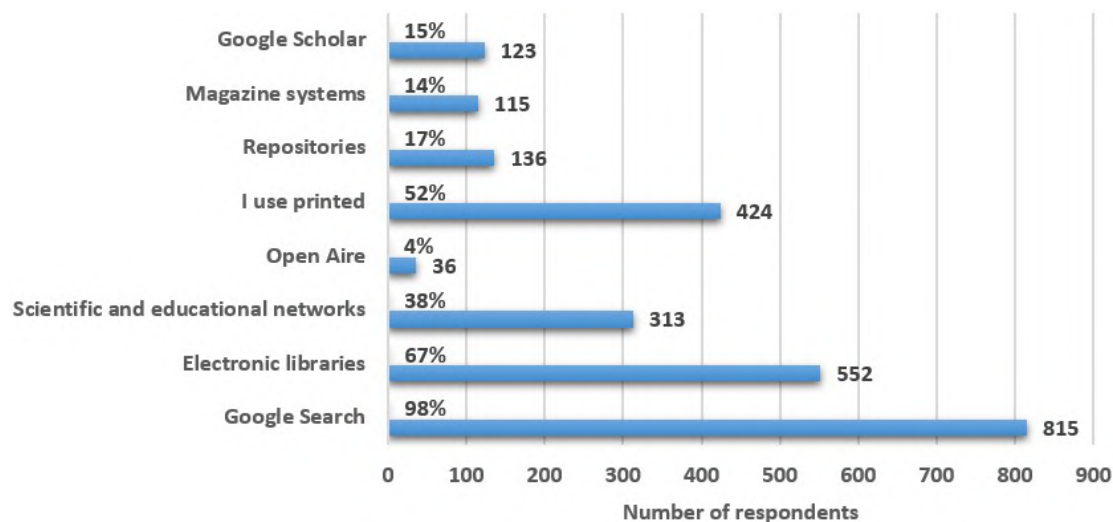


Figure 1: Teachers use services to search for literature.

As can be seen from the chart, 98.9% of respondents (815 respondents) use Google search. Almost half of the respondents (424 people, which is 51.5%) use printed materials to find the right material. At the same time, repositories (16.5%), journal systems (14%) and Google Scholar (14.9%) remain almost unnoticed. It is clear that a rather small number of teachers use open science services (4.4%), as a quarter (only 26.8%) of respondents are familiar with the concept of open science. This is 221 respondents (26.8%) out of 824.

Even fewer respondents know about the European Open Science Cloud – 191 (out of 824 respondents), which is 23.2%. These questions were necessary to clarify the state of awareness of teachers with the latest scientific trends. After all, the use of individual components of the European Open Science Cloud can be quite useful for preparing teachers to work in a scientific lyceum. In addition, the European Open Science Cloud contains about 220 cloud services that teachers can successfully use in the learning process (the main advantage is free and open access). But this is possible only with the appropriate techniques.

Teachers of scientific lyceums must not only bring the scientific component into the educational process, but also be able to organize each stage of research work of students using modern ICT tools. Apparently, one of the leading services can be considered cloud services, because they are focused on the use of anywhere and anytime (on any device) and do not restrict students

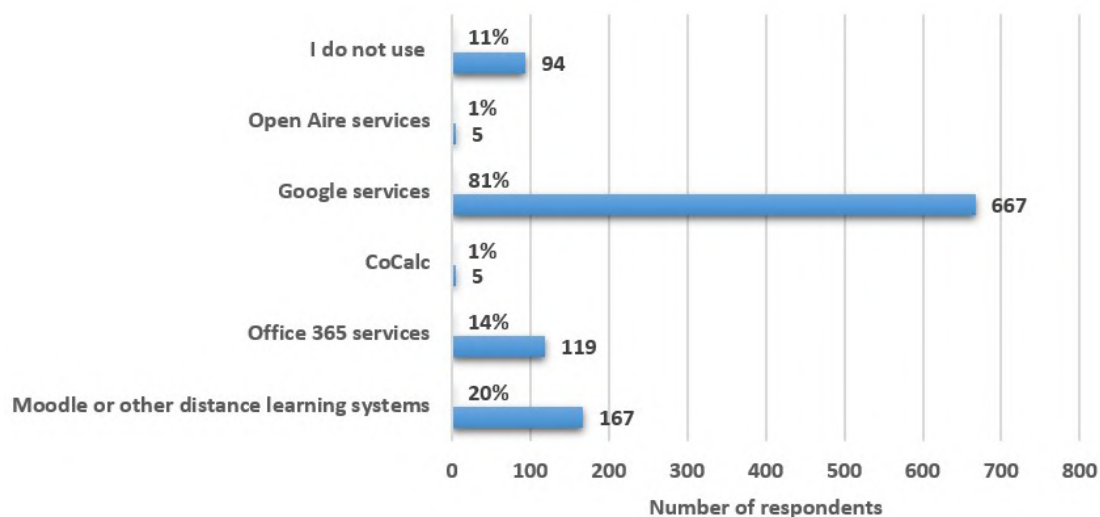


Figure 2: The use of services by teachers to organize the joint work of students.

to use only sufficiently powerful devices (do not depend on the technical characteristics of a device). Therefore, the use of teachers of a service to organize the joint work of students was studied (figure 2). As can be seen from the chart, Google services are the most popular among teachers, they were chosen by 667 respondents (80.9%). Only 20.3% of respondents (167 people) use a system of distance learning courses such as Moodle to organize joint work of students in the classroom. It is unfortunate that 94 respondents (out of 824 respondents, 11.4%) do not use any services to organize group work of students.

The analysis of the answers (figure 2) shows a low level of use by teachers of distance learning systems, specialized cloud services and some tools of the European Open Science Cloud (0.6%). This indicates that there are some problems in preparing teachers of science and mathematics to work in the scientific lyceum, because this situation makes it impossible to fully organize the educational process using modern cloud services, ICT tools at a high, scientific level.

4. Conclusions

Our analysis of the results of the ascertaining stage of a pedagogical experiment on designing a cloud-oriented methodological system for training science and mathematics teachers to work in a scientific lyceum reveals a significant gap in teacher preparedness. While most participants in the experiment recognize the importance of scientific activity for teachers in a scientific lyceum, they are not adequately prepared to engage in such work.

Our observations and interviews indicate that teachers generally do not consider scientific engagement to be necessary, nor do they encourage their students to pursue it. Teachers primarily view conference participation and individual scientific activities as the main avenues for engaging in scientific work, while methodological materials and self-implementation are seen as promising ways to apply and disseminate research findings.

In terms of their use of technology, teachers primarily rely on localized resources and services, limiting their ability to fully leverage the potential of cloud-based open science services. Only a quarter of respondents are familiar with the concept of open science and the European Open Science Cloud.

As a next step, we plan to experimentally implement our cloud-based methodological system for training science and mathematics teachers at Kherson State University, Zhytomyr Polytechnic State University, and Kryvyi Rih State Pedagogical University. The final stage of our research will involve statistical analysis of the results of the formative stage of the pedagogical experiment.

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