PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

MODELO ESTRUTURAL E FUNCIONAL DA METODOLOGIA DE PREPARAÇÃO DE PROFESSORES DE QUÍMICA PARA A APLICAÇÃO DE TECNOLOGIAS DE NUVEM NA ATIVIDADE PROFISSIONAL

STRUCTURAL AND FUNCTIONAL MODEL OF THE METHODOLOGY FOR PREPARING FUTURE CHEMISTRY TEACHERS FOR THE USE OF CLOUD TECHNOLOGIES IN PROFESSIONAL ACTIVITIES

СТРУКТУРНО-ФУНКЦИОНАЛЬНАЯ МОДЕЛЬ МЕТОДИКИ ПОДГОТОВКИ БУДУЩИХ УЧИТЕЛЕЙ ХИМИИ К ПРИМЕНЕНИЮ ОБЛАЧНЫХ ТЕХНОЛОГИЙ В ПРОФЕССИОНАЛЬНОЙ ДЕЯТЕЛЬНОСТИ

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RESUMO

A relevância do estudo deve-se às especificidades de percepção e assimilação de informações pelas crianças em idade escolar (a propensão da geração jovem ao pensamento de clipe) e a um número insuficiente de estudos que revelam as características teóricas e processuais da formação da preparação dos professores de química para usar tecnologias de nuvem em atividades profissionais. O objetivo do artigo é desenvolver um modelo estrutural e funcional da metodologia para preparar futuros professores de química para o uso de tecnologias de nuvem nas atividades profissionais e em seus testes. O método principal para estudar este problema é o método de modelagem, que nos permite considerar o problema em estudo como um processo organizado e focado de desenvolvimento profissional de futuros professores de química e formação da competência no campo das tecnologias de informação e comunicação (TIC), refletindo a capacidade e a vontade do professor. Professor de química usa tecnologia de nuvem em atividades profissionais. O modelo desenvolvido permite não apenas formar o conhecimento dos estudantes sobre as funções das tecnologias em nuvem, mas também visa preparar futuros professores de química para novas condições de atividade profissional. A análise dos resultados da pesquisa mostrou a efetividade do modelo proposto da metodologia para a preparação de futuros professores de química para o uso de tecnologias de nuvem nas atividades profissionais, o que foi confirmado pela dinâmica positiva dos níveis de preparação entre os estudantes do grupo experimental. Os materiais do artigo podem ser úteis para professores e estudantes de instituições de ensino superior, professores de instituições de ensino e especialistas no campo da educação.

Palavras-chave: *modelo estrutural e funcional, tecnologias de nuvem, treinamento profissional, futuros professores de química.*

ABSTRACT

The relevance of the study is due to the specifics of perception and assimilation of information by schoolchildren (the young generation's penchant for clip thinking) and the insufficient number of studies that reveal the theoretical and substantive-procedural features of the formation of preparedness of future chemistry teachers for the use of cloud technologies in professional activities. The purpose of the article is to develop a structural-

functional model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities and its testing. The leading method for studying this problem is the modeling method, which allows to consider the problem under study as a focused, organized process of improving the professional competence of future chemistry teachers and the formation of ICT competency, reflecting the ability and willingness of a future chemistry teacher to use cloud technologies in professional activities. The developed model allows not only to form students' knowledge about the functions of cloud technologies but also aims to prepare future chemistry teachers for new conditions of professional activity. Analysis of the results of the study showed the effectiveness of the proposed model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities, which were confirmed by the positive dynamics of the levels of readiness formation among students of the experimental group. Article materials may be useful for teachers and students of higher educational institutions, teachers of institutions of general secondary education, specialists in the field of education.

Keywords: *structural-functional model, cloud technology, training, future chemistry teachers.*

АННОТАЦИЯ

Актуальность исследования обусловлена спецификой восприятия и усвоения информации школьниками (склонность молодого поколения к клиповому мышлению) и недостаточным количеством исследований, раскрывающих теоретические и предметно-процедурные особенности формирования подготовленности будущей химии. учителя по использованию облачных технологий в профессиональной деятельности. Целью статьи является разработка структурно-функциональной модели методики подготовки будущих учителей химии к использованию облачных технологий в профессиональной деятельности и ее тестирование. Ведущим методом изучения этой проблемы является метод моделирования, который позволяет рассматривать исследуемую проблему как сфокусированный, организованный процесс повышения профессиональной компетентности будущих учителей химии и формирования компетентности в области ИКТ, отражающий способность и готовность будущего. Учитель химии использует облачные технологии в профессиональной деятельности. Разработанная модель позволяет не только формировать у студентов знания о функциях облачных технологий, но и направлена на подготовку будущих учителей химии к новым условиям профессиональной деятельности. Анализ результатов исследования показал эффективность предложенной модели методики подготовки будущих учителей химии к использованию облачных технологий в профессиональной деятельности, что было подтверждено положительной динамикой уровней формирования готовности у студентов экспериментального группа. Материалы статьи могут быть полезны преподавателям и студентам высших учебных заведений, преподавателям общеобразовательных учреждений, специалистам в области образования.

Ключевые слова: *структурно-функциональная модель, облачные технологии, профессиональная подготовка, будущие учителя химии.*

1. INTRODUCTION

Modern information and communication technologies in educational institutions of Ukraine used in the development of electronic educational resources for educational, scientific and managerial purposes have determined the pedagogical community to highlight the issue of updating approaches to the formation of the educational environment of institutions of general environmental education and implementation of a cloud-based learning environment (Litvinova, 2014, Mkrttchian *et al*., 2019; Sinex *et al.,* 2016; Blue and Tirotta, 2011; Cvetkovic *et al.,* 2017; Li *et al.,* 2019; Ovchinnikova *et al.,* 2019; Parmigiani *et al.,* 2019; Zeng, 2016).

This requires a teacher to solve a set of pedagogical tasks aimed at facilitating the assimilation by students of educational material and consideration of the specifics of perception and assimilation of information by the modern generation (Zhitenova, 2019; Collins, 2017; Barak,
2017; Orehovački *et al.,* 2019; Vikhrova, 2017; Wang, 2017). Consequently, new directions appear in the teacher's work: preparing materials of various subjects, modeling processes, creating drawings, mind maps. (Bulvinskaya *et al.*, 2016; Golubeva, 2016; Estapa *et al.,* 2016; Robertson, 2013; Schwenz and Miller, 2014; Zheng *et al.,* 2015).

Modern realities in the education system require a teacher to theoretically comprehend and justify the use of cloud services in chemistry education (Babenko, 2018b; Astafieva *et al.,* 2019; Chamrat, 2019; Kholoshyn *et al.,* 2019; Oddone, 2016; Park and Han, 2016). However, an analysis of practice showed that only a small part of teachers has knowledge of the methodology for creating electronic teaching materials and use them in the educational process. This is mainly due to the inability to use online services and the lack of guidelines for chemistry teachers to create them (Olakanmi, 2017; Qi and Zhao, 2017; Rusmansyah *et al.,* 2019; Sadvakassova and Serik, 2017; Spirin *et al.,* 2018; Tsai *et al.,* 2014).

The aim of the study was to present a structural-functional model of the methodology for preparing a future chemistry teacher for the use of cloud technologies in professional activities in the unity of motivational-target, organizational, content-procedural, and productive-corrective blocks, based on the use of cloud technologies, which allow creating one's own electronic educational materials (visual teaching aids, interactive tasks, and posters, web-quests, didactic and methodological materials, e-portfolio) and include motivational-organizational, cognitive- activity and reflexive stages.

2. MATERIALS AND METHODS

In the research process, the following methods were used: theoretical (analysis, synthesis, generalization and systematization, modeling); diagnostic (observation, testing, survey, conversation, interviewing, questioning); empirical (the study of educational and normative documents, generalization and systematization of the pedagogical experience of teachers and teachers of secondary schools) experimental (ascertaining, formative, generalizing stages) statistical (methods of mathematical statistics).

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

The experimental base of the research was the V. G. Korolenko National Pedagogical University. In addition, individual elements of the methodology were tested on the basis of the Poltava State Agrarian Academy.

The leading research method is the modeling method, which allows us to consider the problem under study as a focused, organized process of improving the professional competence of future chemistry teachers, which consists in the ability and willingness of a future chemistry teacher to use cloud technologies in professional activities. This method involves working in such three stages:

– At the first stage of the study, a theoretical analysis of the existing methodological approaches in the philosophical, psychological and pedagogical scientific literature was conducted, the pedagogical experience of the professional training of future chemistry teachers was studied, and the design plan was formulated.

– At the second stage, a model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities was developed, pedagogical conditions for the implementation of a model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities were identified and substantiated, the pedagogical experiment was conducted and analyzed,

conclusions were clarified.

–At the third stage, quantitative and qualitative processing of the obtained data was conducted, the main points and conclusions of the experimental study were generalized and systematized.

3. RESULTS AND DISCUSSION:

3.1. The structure and content of the model

The methodology of preparing future chemistry teachers for the use of cloud technologies in professional activities is presented in the form of a model in the unity of motivational- targeted, organizational, content-procedural and effective-correcting blocks (Figure 1). The motivation-target block includes the goal (the formation of the preparedness of future chemistry teachers for the use of cloud technologies in professional activities).

Achieving the goal of the developed model of the methodology is based on consideration of the leading conceptual provisions, in accordance with which the authors construct training aimed at enhancing the study and application of cloud technologies in professional activities by future chemistry teachers: competency, activity, personality-oriented, systemic, practice-oriented approaches. The goal and methodological approaches determine the tasks, the selection of the content of the disciplines of the vocational training cycle, forms, methods, and training tools. The organizational block discloses pedagogical conditions and stages of preparation of future chemistry teachers for the use of cloud technologies in professional activities.

The content-procedural block includes the content filling of the disciplines of the vocational training cycle with relevant topics; workshop “Using Google Classroom”, the training course “Cloud Technologies in Education”; master classes: “Modern tools for creating didactic visual aids”, “Application of Google cloud services for the development of research competence”, which systematizes knowledge about various cloud technologies in education, reflects the forms, methods, and means of forming the preparedness of future chemistry teachers to use cloud technologies in professional activity.

The resulting-correcting block of the model provides for both the assessment by experts and the students' mutual and self-assessment of the results achieved in the learning process, the establishment of compliance with their tasks in accordance with the developed criteria and indicators of the preparedness of the future chemistry teacher to use cloud technologies in professional activities. The research results were analyzed on the basis of the developed criteria and indicators of the preparedness of a future chemistry teacher to use cloud technologies in professional activities:

– motivational criterion (formedness of students' motivation and the necessity for the use of cloud technologies in professional activities, interest in the problem of using cloud technologies in professional activities),

– content criterion (completeness and depth of knowledge, the efficiency of knowledge),

– activity criterion (operational skills, the ability to use tools to create one’s own electronic training materials),

– reflexive criterion (formedness of skills to analyze their own educational activities and their results, evaluate their own preparation for the use of cloud technologies in professional activities and the creation of electronic educational materials)

These criteria are the basis for identifying high, sufficient, and low levels of preparedness.

Thus, the developed model of the methodology sets the goal to form the preparedness of future chemistry teachers for the use of cloud technologies in professional activities. The result is the preparedness of future chemistry teachers to use cloud technology in professional activities, which is presented by the criteria and preparedness formation levels. The content of the training is the knowledge that forms the basis of the individual components of preparedness: motivational, cognitive, active, reflexive, formed during lectures, practical, laboratory classes, work with mentors, the work of creative groups of teachers and students, in the process of consultation, independent and individual work, research activities, pedagogical practice, during masterclasses with the use of practice-oriented teaching methods on motivational-organizational cognitive-activity and reflexive stages. The pedagogical conditions for the implementation of the model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities are determined.

3.2. Stages of model implementation

The introduction of the presented model provided the following stages of experimental work:

– determination of the initial level of preparedness of future chemistry teachers for the use of cloud technologies in professional activities using methods of testing, questionnaires, pedagogical observation, statistical processing of research results;

– development and implementation of methodological support for the formation of preparedness of future chemistry teachers for the use of cloud technologies in professional activities in the process of studying the disciplines of the vocational training cycle: the content of disciplines, methodological recommendations and selection of online sources on practical issues of using cloud services, a system of professionally oriented tasks for the development of visual didactic tools and individual and group research projects using cloud technology; research tasks for laboratory studies, e-portfolio. The introduction of methodological support ensured the students' practical mastery of the necessary theoretical knowledge and skills for the effective application of cloud technologies in the professional activities of future chemistry teachers;

– determining the level and dynamics of the formation of the preparedness of the future chemistry teacher for the use of cloud technologies.

The preparatory stage of the study was to develop and adjust the experimental model, to prepare teachers of the disciplines of the vocational training cycle to form the preparedness of future chemistry teachers to use cloud technologies in their professional activities.

The level of the studied preparedness of future chemistry teachers was determined in accordance with the selected criteria and indicators. To check the formation of the motivational criterion, the authors used observation methods, conversations, questionnaires, a test to determine the focus on the acquisition of knowledge (Ilyin, 2002), a scale for assessing the need for achievement (Shiyan, 2018b). To diagnose the formation of the cognitive criterion, students were monitored on the functions and main components of cloud technologies, an analysis of the implementation of complex research tasks (the method of element-wise and operational analysis by A. Usova (2006)), analysis of the results of the current, modular and final control. The formation of the activity criterion was checked by analyzing the practical actions of students in carrying out individual research tasks, using methods of expert assessments, observation, interviews, the method of “Incomplete decisions” (Friedman *et al.,* 1988). Formedness of the reflexive criterion was diagnosed according to the method of A. Karpov (2004) and by questioning students.

At the ascertaining stage of the pedagogical experiment (the 2016-2017 academic year), it was established that only 10.88% of students have a high level of motivation and need to develop knowledge, skills, and abilities to apply cloud technologies in professional activities; 2.72% of students have a high level of knowledge about cloud technologies and tools; 2.04% of students are able to use cloud technology and create their own electronic educational resources; 23.81% of students recognize the importance of using cloud technology in their professional activities (Derkach and Starova, 2017). The formative stage of the pedagogical experiment (the 2017-2018 academic year) was conducted in accordance with the developed model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities. The effectiveness of the model was tested in two ways: a sequential and parallel experiment. The number of students who took part in the pedagogical experiment at its formative stage was 147 people, of which the experimental (75 people) and control (72 people) groups were formed.

The motivational-organizational stage of the methodology was aimed at students recognizing the importance of using cloud technologies in future professional activities, developing their interest in creating their own electronic educational resources (Babenko and Komar, 2018). For this purpose, electronic educational resources were used in laboratory studies. To maintain interest in acquiring new knowledge and practical skills as a permanent incentive mechanism for cognition, electronic educational resources were chosen in such a way that their content corresponded to the cognitive needs of future chemistry teachers, was interesting, accessible and at the same time complex, thereby encouraging students to work with cloud computing technology.

Students were also offered interactive exercises, crosswords, web quests, puzzles, and the like. The motivation trainings for creating an electronic portfolio also turned out to be effective at this stage, where they considered the possibilities of using e-portfolios to develop creativity, present their own achievements and increase competitiveness in the labor market, focused on the detailed disclosure of the principles of maintaining an electronic portfolio by students during their training, on tools, creating an

electronic portfolio based on cloud services.

Before students created an electronic portfolio, the structure of which was determined by the topics provided by the work programs of the disciplines, it was proposed to use such cloud services as Blogger.com. and Sites.google.com. Students also did hands-on learning of the Google Classroom Learning Management System in the "Using Google Classroom" workshop. The indicated forms, methods, and teaching aids contributed to the formation of interest in obtaining new knowledge and practical skills for their further productive use, formed the desire for self-improvement, as well as establishing communication, optimizing teamwork, which subsequently had a positive impact on the organization of effective student activities the team.

At the cognitive-activity stage of the model, the methods formed the knowledge system of future chemistry teachers about the basic components of a cloud-based learning environment, studied the characteristics, functionality and tools of cloud services (Derkach, 2011; Derkach, 2013). For this purpose, lectures-visualisations, interactive lectures were used. Lectures were held using technical teaching aids, namely, demonstration of the elements of lecture material using various types of cloud technologies: a multimedia system (screen, laptop, projector) or a multimedia board.

The laboratory works were conducted using the appropriate software: a multimedia board, Google Chrome, online services, the Google Classroom learning management system. Methodological recommendations for the laboratory work included the following components: topic, purpose, equipment description, list of training results, instructions for conducting practical works, resources and files for the use of video materials and a virtual (simulation) experiment (if necessary), visual material of theoretical information topics for show students visualization examples, characteristics of their usage in the learning process, comparison and evaluation of visual identical chemical content created by different instruments. Control over the implementation of tasks and consultations took place, except for the audience, in the online mode of the Google Classroom learning management system. The means of controlling knowledge and skills in chemical disciplines were diversified using cloud services (tests, computational and graphic tasks, interactive tasks, logical exercises, research tasks, quests) with commenting and self- control.

Particular attention was paid to mastering by future teachers the skills of planning and organizing independent work in order to achieve maximum productivity, which is an important factor in successfully preparing for classes, completing additional tasks, studying external resources (LearningApps.org, Flippity). Group working methods were implemented by a combination of research and design activities using the popular Google Forms and Kahoot services to search for topics and posed a research problem, Padlet service for organizing a discussion of the problem, Google Docs services, and Google Sheets for joint creation, editing, formatting of documents and adding comments, Mindmeister.com, Mindomo.com, Bubbl.us services for visualizing materials, Prezi, Canva, Padlet services for presenting the results.

Additional tasks related to future professional activities were proposed for laboratory studies, which took into account the real professional functions of a chemistry teacher, the solution of which required the use of observation skills, analysis, synthesis and generalization of the necessary information, brainstorming methods, mind mapping, inverted training, research method, project method, portfolio, computer modeling. The development of the content and tools of cloud services was facilitated by the training course "Cloud Technology in Education". The workshops were also effective: "Modern tools for creating didactic visual aids", "Use of Google cloud services for the development of research competence," and others.

At the reflexive stage, self-analysis and adequate self-esteem of students were facilitated by the creation of an e-portfolio, student forums and chats, and pedagogical mentoring. For the presentation by students of personal achievements in educational activities, the authors used such cloud services as Resume and Kartatalanta.ru. Student forums with participation of stakeholders helped future chemistry teachers establish their own level of preparedness for professional activity with the requirements of employers. Participation in student scientific conferences and seminars, working with mentors, provided students with practical experience in presenting research results, and testing the created electronic educational resources in real conditions of a comprehensive school.

The conducted experimental work made it possible to prove the effectiveness of the identified pedagogical conditions for the implementation of the developed model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities.

It was proved that by implementing the first condition – using Google Classroom to create virtual interaction between the participants of the educational process – there was an expansion of communication tools and ensuring feedback efficiency, planning of the educational process, storage of files and links to information sources, distribution of educational materials, creation of educational content, organization of students' joint work, effective communication between students and a teacher, creation of virtual educational communities in the organization and questionnaires, surveys, monitoring and evaluation of learning outcomes.

Users in the virtual classroom also interacted through gaming activities, namely the organization of web quests. For students, they offered, for example, the methodical quest “Interactive exercises in chemistry”, which included working with computer programs and using the Internet, including cloud technology. Each participant received a task that included creating a mind map using Mindmeister.com, creating exercises, crosswords using Learning Apps, creating tests using Google Forms on the relevant topics, then switched to an e-class and sent the completed task to the teacher. A teacher immediately checked the assignment and set the score (encoded letter of the alphabet). Students composed words from encrypted letters and published them in the classroom. The team jointly summed up the results of each assignment, the participants exchanged materials to achieve a common goal – to create a collection of interactive exercises in chemistry.

The implementation of the second pedagogical condition – the use of cloud services for the organization of educational and research activities of future chemistry teachers – contributed to the practical preparation of students for future professional activities, due to which there were a better understanding and perception of educational material by students, the acquisition of professional experience in the classroom by involving them in creative oriented activities. The directions of using cloud services for organizing the educational activities of future chemistry teachers are proposed, namely: learning management, systematization, and presentation of educational material, communication of participants in the educational process, monitoring, and evaluation. In order to attract future chemistry teachers to organize research, the authors used Google’s cloud services to select research information resources (Google Academy, Google Books), create electronic notebooks (One Note), save a lot of information and work with documents (Google Drive), conducting online surveys (Google Form), electronic document management (Gmail, Google Docs), planning support and organization of work (Google Calendar).

Implementation of the third pedagogical condition – providing pedagogical support for students to create their own electronic learning resources (visual teaching aids, interactive tasks, and posters, web-quests, didactic and methodological materials, e-portfolio.) during classes and in extracurricular activities – contributed to the disclosure of the personal potential of a future teacher by providing specific assistance to him in overcoming difficulties in learning, in self-determination and self-realization of a personality of a future specialist, attracting them to active, creative work (the implementation of individual and group research projects with the subsequent presentation of the results at a meeting of the regional round table “Cloud Services in Education”, conducting master classes on creating didactic visual teaching aids, interactive electronic exercises and posters in chemistry for students, teachers, schoolchildren, work with mentors.).

The main ways of providing pedagogical support to future chemistry teachers during classes and in extracurricular activities were pedagogical counseling and pedagogical mentoring. The main forms and methods of work of teachers-mentors with students were masterclasses, training, conversations, and discussions on various methodological topics; discussion of the possibilities of using various electronic educational resources in the lessons, joint design of lessons, their detailed analysis; counseling on the organization of educational and cognitive activities and the like. A great role was played by a mentor for future chemistry teachers to test their own developments, research activities, pass pedagogical practice. Based on this, the main attention was paid to supporting the initiative, creative search, independent improvement of the professional competence of future specialists.

According to the results of psychological and pedagogical diagnostics of the phenomenon under study at the formative stage of the experiment in the EG, a significant increase in the level of formation of preparedness of future chemistry teachers to use cloud technologies in professional activities was revealed (Table 1). The reliability of the obtained experimental work data was checked using the χ^2 Pearson criterion. With a confidence probability of $p = 0.01$, comparing the levels of formation of preparedness of future chemistry teachers for the

use of cloud technologies of the experimental and control groups showed that χ^2-emp.> X^2-cr. by all criteria.

An analysis of the results of the experimental work showed the effectiveness of the proposed model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities, which is confirmed by the positive dynamics of the levels of preparedness formation among students of the experimental group. In particular, indicators of a high level of the motivational criterion for students of experimental groups increased from 12% to 64%, cognitive – from 2.7% to 24%, activity – from 2.7% to 20%, reflexive – from 24% to 49.3 % At the same time, the number of students with a low level of preparedness of future chemistryteachers for the use of cloud technologies in professional activities according to all criteria decreased in the experimental group. No significant changes were found in the indicators of the research competence of students in the control group. The reliability of the data obtained is confirmed by the method of mathematical statistics (χ^2 Pearson criterion), which in the experimental groups showed a significant advantage of empirical values of the indicators over critical ones at a probability level of 99%.

A theoretical analysis of the problem under study in pedagogical theory and practice showed the absence of special studies on the preparation of future chemistry teachers for the use of cloud technologies in professional activities. However, the studies of N. Burinskaya (1987), L. Velichko (2013), V. Starosta (2006), N. Shiyan (2018a), O. Yaroshenko (Yaroshenko et al., 2016) are devoted to the formation of general pedagogical skills of a future chemistry teacher. ICT, as a means of teaching chemistry, was considered in their works by T. Derkach (2016), E. Babenko (2018a), E. Ratkevich (1998), N. Titarenko (2004).

Pedagogical conditions contribute to the preparation of future chemistry teachers for the use of cloud technologies in their professional activities: the use of Google Classroom to create virtual interaction between participants in the educational process; use in the process of preparing future chemistry teachers to cloud services for educational and research activities; providing pedagogical support for students to create their own electronic learning resources (visual teaching aids, interactive tasks and posters, web quests, didactic and teaching materials, e-portfolios) during classes and in extracurricular activities.

Using Google Classroom virtual classroom to support the educational process and learning management promotes open access to the educational information environment; filling the content of the virtual classroom with the necessary methodological, educational, methodological and scientific developments; the establishment of the value priorities of future chemistry teachers, in particular, the steady desire to be competent in the chosen profession, internal motivation to use cloud technologies in professional activities, the ability to carry out effective learning activities, and the willingness to take responsibility for its results; the creation of auxiliary ELR (visual materials, practice-oriented tasks, tests, presentations, guidelines, electronic collections, dictionaries.). Building trust with students is facilitated by the fact that the teacher in the virtual classroom acts as a facilitator, as a result of which students can freely express their opinions and defend their own position reasonably. On this basis, the independence and initiative of the participants in the educational process are formed, their personal growth, creative development are stimulated, and skills to navigate in non-standard situations are developed.

4. CONCLUSIONS:

As a result of the study, it can be concluded that the effectiveness of using cloud services in the process of preparing future chemistry teachers for educational and research activities depends on the correct selection of hardware and software, the integration of methods and forms of activity, and the system of pedagogical tasks. The integration of cloud, research, and design technologies ensures the formation of both subject competence of future specialists and readiness for the introduction of cloud technologies, as it simplifies their understanding and assimilation of the essence of cloud technologies and the mastery of their tools. The creation by students of their own electronic learning resources stimulates the assimilation of new knowledge and new ways of working, improving practical skills, ensures the intensification of cooperation among participants in the educational process, promotes the professional development of future chemistry teachers, and immerses them directly in the field of professional activity.

Meetings with mentors contribute to the realization of the importance of obtaining the necessary theoretical knowledge and practical skills to apply cloud technology in professional activities, providing the opportunity to feel in the role of a teacher, forming personal practical experience, motivation to use cloud technology in

solving professionally-oriented tasks, and comparing the level of formation of one's professional competence to requirements of employers and adjusting their own educational trajectory. Students check their own developed electronic educational resources in the real conditions of a general educational institution, find out the feasibility of choosing a tool, and make adjustments to the creation of educational products.

The rapid development of cloud technologies and their inclusion in the practice of modern education indicate the need for special training of future chemistry teachers for the use of cloud technologies in their professional activities. The proposed model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities is focused on the gradual mastery of the basic principles and modern tools of cloud services by students.

Article materials may be useful for teachers and students of higher educational institutions, teachers of institutions of general secondary education, specialists in the field of education. The study does not exhaust all aspects of the formation of the readiness of future chemistry teachers to use cloud technologies in their professional activities. Prospects for further research include the use of virtual and augmented reality technologies in preparing future chemistry teachers for the use of cloud technologies in professional activities.

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Table 1. *Diagnostic results of the preparedness of future chemistry teachers to the use of cloud technology in professional activities at the ascertaining and formative stages of the experiment*

No	Criteria	Experimental group 75 persons, %						Control group 72 persons, %					
		ascertaining stage			formative stage			ascertaining stage			formative stage		
		l	m	h	l	m	h	l	m	h	l	m	h
1	Motivational	41.3	46.7	12	2.7	33.3	64	38.9	51.4	9.7	16.7	62.5	20.8
2	Cognitive	76	21.3	2.7	9.3	66.7	24	76.4	20.8	2.8	52.8	30.5	16.7
3	Activity	78.7	18.6	2.7	17.3	62.7	20	79.2	19.4	1.4	47.2	37.5	15.3
4	Reflexive	45.3	30.7	24	5.4	45.3	49.3	44.4	32	23.6	16.7	45.8	37.5

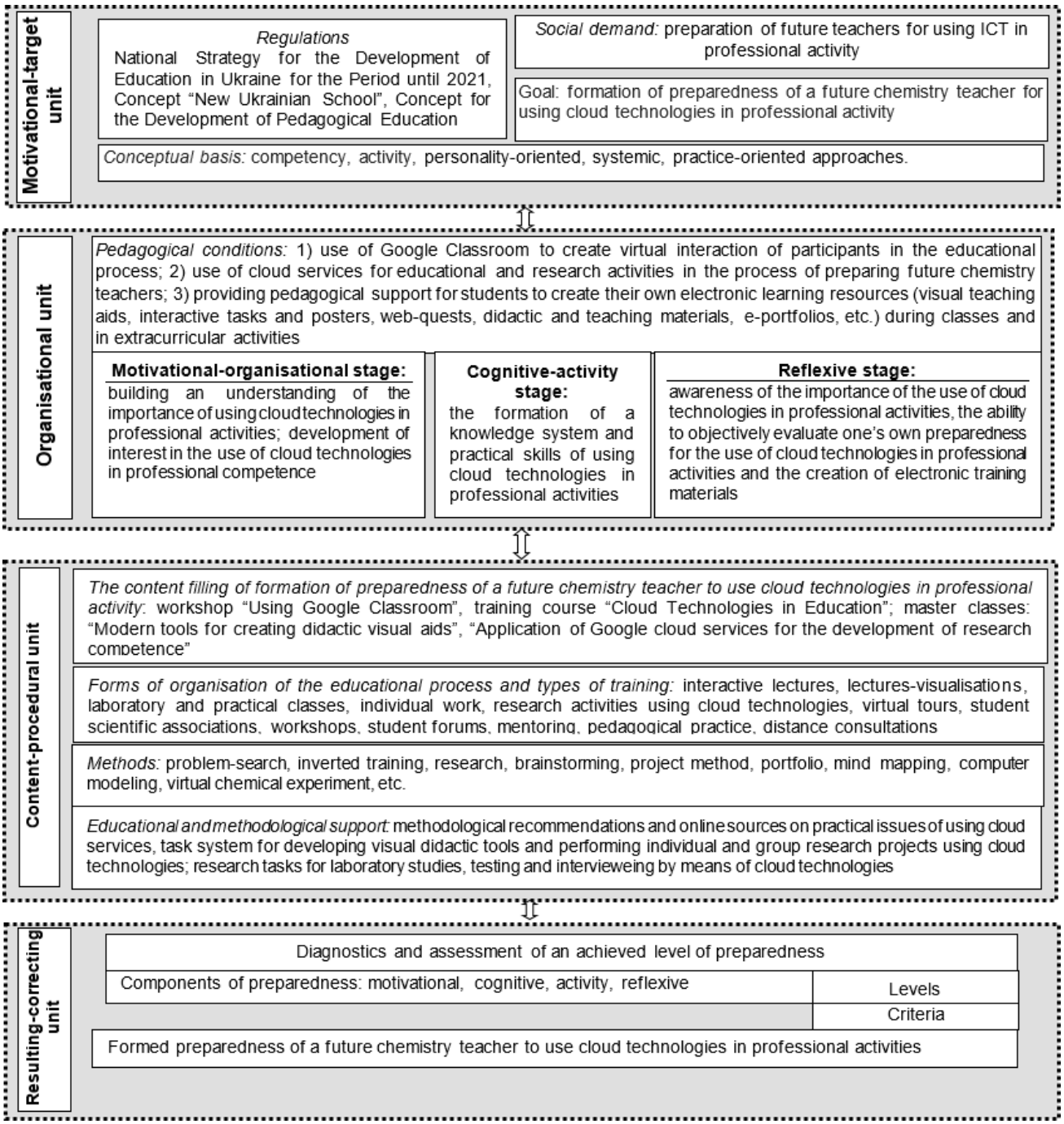

Figure 1. *The model of the methodology for preparing future chemistry teachers for the use of cloud technologies in professional activities*