DESENVOLVIMENTO DE HABILIDADES ESPECIAIS EM QUÍMICA NO SISTEMA DE FORMAÇÃO PROFISSIONAL UNIVERSITÁRIA DOS ALUNOS**DEVELOPMENT OF SPECIAL CHEMISTRY SKILLS IN THE UNIVERSITY VOCATIONAL TRAINING SYSTEM OF THE STUDENTS****ФОРМИРОВАНИЕ СПЕЦИАЛЬНЫХ УМЕНИЙ В ОБЛАСТИ ХИМИИ В СИСТЕМЕ ПРОФЕССИОНАЛЬНОЙ ПОДГОТОВКИ СТУДЕНТОВ ВУЗА**

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RESUMO

A preparação dos estudantes para o trabalho na área de educação contribui para o desenvolvimento da educação escolar. A base de ensino dos estudantes é constituída por técnicas, métodos e formas de ensino a partir do exemplo da atividade prática e da execução de ações profissionais. A utilização de tecnologias informáticas de informação (TIC) no ensino superior promove: divulgação, preservação e desenvolvimento dos interesses individuais; a formação de interesses cognitivos, o desejo de autoaperfeiçoamento e autorrealização dos alunos; assegurar a complexidade do estudo dos fenômenos da realidade, a continuidade da relação entre as ciências naturais, a tecnologia, as humanidades e a arte; atualização dinâmica constante de conteúdos, meios, formas e métodos de ensino e educação. O objetivo do artigo é identificar o nível de formação de competências em informação e comunicação dos futuros professores da química. No início, foi realizado um inquérito a 24 professores das disciplinas de formação profissional geral e das disciplinas de formação profissional que leccionavam para estudantes da direção de formação “Tecnologia Química”. A pesquisa foi direcionada; foram utilizados questionários tanto na forma eletrônica (*Google Form*) quanto impressa. O artigo mostra como se forma a competência informacional dos futuros professores de química. O significado prático do estudo é determinado pela necessidade de combinar o nível de educação escolar com as tendências tecnológicas modernas. Mostra-se a necessidade de formação do interesse individual dos estudantes pela atividade científica. Verificou-se que a aquisição de competências, experiência em sistemas abertos de formação, na opinião de todos os respondentes, é condição necessária para a implementação de novas atividades educacionais, cognitivas e profissionais eficazes. A etapa de verificação da experiência pedagógica estabeleceu a necessidade de seleção e implementação de tecnologias móveis, informáticas e de nuvem no currículo para a resolução de problemas de orientação profissional. A novidade da pesquisa é determinada pela necessidade de aprimorar a competência dos estudantes em uma universidade pedagógica no ensino de disciplinas químicas.

Palavras-chave: *ambiente de informação, tecnologias de informação e comunicação, processo educacional, questionamento.*

ABSTRACT

Preparing students for work in the field of education contributes to the development of school education. The basis for teaching students is made up of techniques, methods, and forms of learning by practical activity and the implementation of professional actions. The use of information and communication technology (ICT) in higher education contributes to the disclosure, preservation, and development of individual interests; the motivation; the desire for self-improvement and self-realization of students; ensuring the complexity of studying the phenomena of reality, the inextricability of the relationship between science, technology, the humanities, and art; a constant dynamic update of the content, means, forms, and methods of training and education. This study aimed to identify the level of future chemistry teachers through ICT competence development. A survey was conducted among 24 teachers of general professional and subject-vocational training, who taught “Chemical Technology” to their students. The questionnaire was targeted; the questionnaires were used both in electronic format (*Google form*) and in print. The article shows how information competence for future chemistry teachers is developed. The

practical significance of the study is determined by the need to match the level of school education with modern technological trends. It is shown that there is a necessity for the motivation of students in scientific activity. It was established that the acquisition of competencies and the experience in open training systems, according to all respondents, is a prerequisite for the implementation of further effective educational, cognitive, and professional activities. The ascertaining stage of the pedagogical experiment established the need to choose and introduce the disciplines of mobile, computer, and cloud technologies into the curriculum for solving professionally-oriented problems. The novelty of the study is determined by the necessity to increase the competence of the pedagogical university students in training how to teach chemical disciplines.

Keywords: *information environment, information and communication technologies, educational process, questionnaires.*

АННОТАЦИЯ

Подготовка студентов для работы в области образования способствует развитию школьного образования. Основу для обучения студентов составляют приемы, методы и формы научения на примере практической деятельности и выполнения профессиональных действий. Использование информационных компьютерных технологий (ИКТ) в высшем образовании способствует: раскрытию, сохранению и развитию индивидуальных интересов; формированию познавательных интересов, стремлению к самосовершенствованию и самореализации студентов; обеспечению комплексности изучения явлений действительности, неразрывности взаимосвязи между естествознанием, техникой, гуманитарными науками и искусством; постоянному динамическому обновлению содержания, средств, форм и методов обучения и воспитания. Целью статьи является выявление уровня сформированности ИКТ-компетентности будущих учителей химии. В начале был проведен опрос 24 преподавателей дисциплин общепрофессиональной и предметно-профессиональной подготовки, которые преподавали для студентов направления подготовки «Химическая технология». Анкетирование было адресное, использовались анкеты, как в электронной (Google форме), так и в печатной форме. В статье показано как формируется информационная компетентность у будущих преподавателей химии. Практическая значимость исследования определяется необходимостью соответствия уровня школьного образования современным технологическим тенденциям. Показано, что существует потребность в формировании также интереса у учащихся к научной деятельности у отдельных учащихся. Установлено, что приобретение компетенций, опыт работы в открытых системах обучения, по мнению всех респондентов, является необходимым условием для осуществления дальнейшей эффективной учебно-познавательной и профессиональной деятельности. Констатирующий этап педагогического эксперимента установил потребность в выборе и внедрении в учебные программы дисциплин мобильных, компьютерно- и облачных технологий для решения профессионально ориентированных задач. Новизна исследования определяется необходимостью повышения компетентности у студентов педагогического вуза при обучении преподавания химических дисциплин.

Ключевые слова: *информационная среда, информационно-коммуникационные технологии, образовательный процесс, анкетирование.*

1. INTRODUCTION:

The use of information and communication technology (ICT) in higher education contributes to the disclosure, preservation, and development of individual interests; the motivation; the desire for self-improvement and self-realization of students; ensuring the complexity of studying the phenomena of reality, the inextricability of the relationship between science, technology, the humanities, and art; a constant dynamic update of the content, means, forms, and methods of training and education (Cai *et al.*, 2014; Viera *et al.*, 2017; Wang *et al.*, 2019; Wei Wen Wong *et al.*, 2020). The main pedagogical goals of using ICTs are (1) the development of the students

personality, his/her preparation for a comfortable life in an informational (digital) society: the development of various types of thinking and communication skills; the formation of an aesthetic culture through the visualization of information using computer graphics programs, multimedia technologies; the development of skills to find optimal solutions in unforeseen difficult situations; the development of skills to carry out experimental research activities – computer modeling, research of the latest ICT tools; building an information culture, and the ability to process diverse information through appropriate software; (2) the implementation of the social order following the needs of the information society and the stage of its informatization: training of specialists in the field of ICT; training of users in PC hardware and

software; (3) the intensification of all levels of the educational process: improving the efficiency and quality of the educational process through the implementation of the entire didactic potential of ICT; providing increased motivation for learning through computer visualization of information, the ability to manage students, the interaction of the educational process of subjects; the expansion and deepening of intrasubject communications through the use of modern means of processing text, graphic, audiovisual information in solving problems from various subject areas and the like (Stromov *et al.*, 2018; Rootman-le Grange and Retief, 2018; Guseinova, 2018; Oreshkina and Dvulichanskaya, 2019; Shcherbakova and Ilina, 2019).

The ICT-based lessons are fundamentally different from the traditional teaching system (Kondo and Fair, 2017). This difference is in changing the role of the teacher: he/she is no longer the main source of knowledge, his/her function is reduced to an advisory and guiding figure (Tomaszewski, 2016). It is due to modern electronic textbooks, virtual chemical laboratories, the Internet, and new teaching aids. The task of the teacher is to select these tools following the content of the educational material, age, and psychological characteristics of the students, as well as the ability of students to use a computer (Sigmann, 2018). The purpose of using a computer in a chemistry lesson is to create a didactically active environment that promotes productive cognitive activity while mastering new material, developing the students thinking, and increasing the motivation for the subject being studied. (Jones and Seybold, 2016; Álvarez-Chávez *et al.*, 2019).

There are the following forms of ICT in chemistry lessons: multimedia presentations, video experiments; testing; distance learning; multimedia laboratory and practical work; research and project activities, use of electronic textbooks (Martin *et al.*, 2020). Besides, computer technologies contribute to as follows: finding additional sources of information for teachers and students; making wider use of audiovisual means to increase the clarity of the material, for better understanding by the students; accompanying educational material with dynamic pictures; simulating processes that cannot be reproduced under normal conditions; reproducing chemical experiments with hazardous, toxic, and explosive reagents; conducting quick and effective testing of students. It also helps to carry out an individual trajectory of teaching students, the possibility of their growth and development; to organize

individual work of students with information, their ability to self-prepare for laboratory and practical work, final control of knowledge, preparation of their own research; to conduct distance training of students in case of their illness or other reasons; to organize post methodological works of the teacher and creative works of students on various sites (Devitt *et al.*, 2020; Zinn *et al.*, 2020; Pekdağ, 2020).

This study aimed to identify the level of future chemistry teachers in ICT competence development.

2. LITERATURE REVIEW:

The development of information and communication technologies (ICT) has led to qualitative changes in the information environment surrounding an individual, which in turn has caused a chain of qualitative changes in all areas of his/her existence (Fernández De Aránguiz *et al.*, 2014). In the field of education, these changes are classified as a shift in the main paradigm: while in the past, a teacher was the main source of professional information for the students, which made the reproductive teaching methodology the leading one, now a student has many available sources (McCollum *et al.*, 2016; Maslennikova and Gibadulina, 2019). A teacher's function becomes different: he/she must teach students to navigate in the information environment, develop their creative and intellectual abilities, including the capacity for self-instruction (Muravyeva *et al.*, 2015; Sazhina *et al.*, 2017; Sazhina *et al.*, 2019).

Significant trends in the development of education in the information society include as follows: continuity of education; the interdependence of education, science, and culture; strengthening the prognostic orientation of education; creation of an educational information environment; creation of a single information educational space of a country and its integration into the global information educational space; personal orientation of education; humanization of education; humanization of the educational process; fundamentalization of education; integrity of education; priority of the moral component; finding the right combination of students freedom, responsibility and self-restraint as the main regulators of their activities; the formation of a personality with value orientations; cultural integrity of education; the natural integrity of education; the formation of chemistry as a meta-subject; deepening the worldview function of chemistry in education (Muravyeva *et al.*, 2018;

Sigmann, 2018).

The integration of ICTs in education can occur as follows: a tool for cognition; an object of study; teaching aids (Peters, 2014), personality development, communication, automation of diagnostic processes for the results of educational and cognitive activities, automation of experimental results, and organization of intellectual leisure (Nunes-Da-Cunha and Fernandez-Llimos, 2019). To implement the tasks of educational informatization, considering the stages and trends of its development, one should look for new approaches to building and organizing the educational process (Tornee *et al.*, 2019), building appropriate pedagogical systems that reflect the effective training of the future generation, in particular, future chemistry teachers, to livelihoods in the information society (Yokono and Mitsuishi, 2012).

The ideological level of informatization should be supported by developing the scientific foundations of the methodology (Emde and Emmett, 2007). These include a systematic analysis of the development and implementation of information technologies, the development of new principles for organizing the educational process (Ovchinnikov *et al.*, 2018), the creation of descriptions of subject areas and chemical models that arise from the formalized functional tasks and the ones that are difficult to formalize, and the development of basic information technologies in the form of interactive tools (Kirova, 2015).

The activities of the Higher School in the information society should be based on a modern educational paradigm: student and information resources, student and technologies, as well as student and teacher (MacDonald, 2018). The implementation ensures the construction of the educational process based on the activity approach (Lou, 2012), which involves the use of active and interactive teaching methods to provide students with an understanding of “where?” and “how?”. It is possible to apply the acquired knowledge to professional activities (Šumiga, 2015); to introduce the modern pedagogical technologies of personality-oriented and humanistic approaches; to integrate the information (computer and telecommunication) technologies into the existing and future innovative pedagogical technologies (Peters, 2011; Nunes-da-Cunha *et al.*, 2019).

The introduction of information technology as a means of innovative development of education is not only positive but also

controversial (and in some aspects, negative), which should be considered to avoid the deformation not only of a specific result but of the entire education system (Jones and Seybold, 2016). There are the following negative aspects (problems): the lack of proper investment by some leaders in the process of implementing the information technologies; higher education institutions inappropriate use of forms and methods of cooperation with the organizations that produce educational services to improve the quality of students training and teachers qualifications; insufficient equipment, often outdated material and technical base in many universities; the inappropriate, sometimes excessive use of certain technologies (e.g., hypertext links, media texts) in the educational process, as the unlimited access to educational resources often scatters and prevents students from focusing on educational material (Tzvetko and Boiadjev, 2013).

In addition to the above-mentioned problems on the effective use of ICTs in education, requiring in-depth analysis and solutions, there are also ontological problems (the coexistence of the real and virtual worlds and ways to distinguish them; artificial intelligence, its impact on personality development); epistemological problems (identification of information and knowledge; the search for new ways to build knowledge using ICTs; the definition of network systems that facilitate the dissemination of knowledge); identity issues (online security; online identity) (Falicoff *et al.*, 2014).

3. MATERIALS AND METHODS:

First, a survey was conducted among 24 teachers of general professional and subject-vocational training disciplines who taught “Chemical Technology” to their students. (Kazan Federal University, Kazan, Russian Federation). The questionnaire was targeted and used in electronic format (Google form) and in print (APPENDIX 1). Among the teachers who took part in the questionnaire, 8 were under 35, 10 – from 35 to 44 years old, 3 people each – from 45 to 54, and more than 55 years old. In the second part of the ascertaining stage of the pedagogical experiment, 22 chemistry teachers took part.

To identify the level of the future chemistry teachers ICT competence development at the end of 2017/2018 and the beginning of 2018/2019, the pedagogical experiment (a survey) was conducted. The purpose of which was to clarify

the motives that encourage students to study and use ICTs in educational and cognitive activities and solving professional problems; the conditions of preparation for the use of ICT for solving professional problems, the availability of educational and methodological support for solving professional problems; the willingness of future chemistry teachers to study ICTs for solving professionally-oriented tasks, which envisages the development of diverse types of electronic educational resources and their testing in a simulated educational environment.

The ascertaining stage of the pedagogical experiment included the following stages: to learn from the teachers, who have trained future chemistry teachers, the level of integration of ICT into professional activities, their ICT competence self-assessment with a focus on the integration of ICT during the educational activities and in the teaching of disciplines in their subject area; the determination of ICT competence for chemistry teachers based on an adapted methodology proposed by UNESCO; the level of ICT competence and students attitudes towards the use of ICT, in particular, multimedia tools, electronic educational resources, subject-oriented tools (mobile, computer-oriented, and cloud-based mathematical systems) in the process of educational and cognitive activity, and solving professional problems.

The formative stage of the pedagogical experiment was carried out according to the developed research methodology among 2nd and then 3rd-year students of the "Chemistry" training direction. That is, the formative stage of the pedagogical experiment started in the 4th semester with the subject "Multimedia Fundamentals" (Stage 1) and ended in the fifth semester with the subject "Packages of Chemical Programs" (Stage 2). It is worth to note that due to a decrease in the enrolment of students in the studied years and almost identical changes in the results before the start of the experimental work, for the purity of the experiment, it was decided to form three experimental (EG) and one control (CG) groups. That is, two experimental groups were studied: EG1, which consisted of 57 students of the 2nd year of study in the 4th semester of 2018/2019 and the 5th semester of 2019/2020; EG2 – 61 students of the 4th semester of 2019/2020 and the 5th semester of 2016/2017. In the experiment, it was decided that students of the "Chemistry" direction who studied in 2019/2020 would comprise the control group CG1 (63 students), and students of 2016/2017 – the experimental group EG3 (70 students), in

which the developed methodology was partially introduced in the second year in the framework of the discipline "Informatics" (the materials of the disciplines "Multimedia Fundamentals" and "Packages of Chemical Programs"), and the materials of the educational and methodical manual "Packages of Chemical Programs in the Training of Future Chemistry Teachers" were used in the educational process by the teachers of chemical disciplines. Besides, the students participated in training and consultation webinars.

In the final part of the ascertaining experiment with 217 1-4-year full-time mode students educated in Chemistry Teaching and those of the 5th year of study on specialty "Chemistry Teacher", it was planned to identify the attitude and ability of future chemistry teachers to use multimedia technologies, computer, cloud, mobile technologies, in particular, chemical systems, in educational, cognitive, and professional activities.

At the beginning of the formative stage of the pedagogical experiment in the experimental and control groups, the level of ICT competence development and its influence on the solution of professionally oriented problems by future chemistry teachers were diagnosed. To determine the dynamics of all the components of ICT competence according to the selected criteria, levels, various methods were used by the authors and adapted to study ICT competence.

The verification of the cognitive criterion consisted of the verification of technological (T), general professional (GP), and subject-professional (SP) components of ICT competence. To test the criterion, different types of questions and tasks were used, constructed by the objectives of the cognitive sphere by B. Blooms taxonomy (structure of the cognitive process), modified by L. Andersen and D. Kratvol. In particular, some tasks required students to independently choose the technologies for their solution since it did not indicate which ICT tools should be used to solve a given task. Similarly, verifying the operational-technological criterion includes verifying the technological, general professional, and subject-professional components of ICT competence. It was built on the solution of professional problems: competence-based tasks and a set of chemical tasks (test), to identify practical skills in using ICT in solving them and surveying.

The determination of the criteria formation level, which implied the use of several diagnostic methods, is calculated as the

arithmetic means of the Equation (Equation 1), where n – the number of techniques used x_i – the result of the i -th technique. The indicator of the general development of ICT competence is calculated similarly as an average sample value for all individual criteria. To determine the homogeneity of the sample in terms of the level of ICT competence development, the following hypotheses were formed at the beginning of the formative stage of the pedagogical experiment:

1. Null hypothesis N –: the distribution of indicators of the levels of ICT competence development in EG1, EG2, EG3 does not differ from the indicators of the level of ICT competence development in the CG. That is, they belong to the same general population.

2. Alternative hypothesis H_1 : the distribution of indicators of the levels of ICT competence development in EG1, EG2, EG3 differs from the indicators of the level of ICT competence development in the CG, respectively, that is, they do not belong to the same population.

To test the statistical hypotheses the Pearson criterion χ^2 is used, since all the requirements necessary for its use are fulfilled (Equation 2), where n_1 , n_2 – the number of students in the experimental and control groups; Q_{1i} and Q_{2i} – the number of students in the experimental and control groups, respectively, who have the i -th level of knowledge ($n=1$ – “low”, $n=2$ – “medium”, $n=3$ – “sufficient”, $n=4$ – “high”)

To determine the Pearson criterion, all 251 students of the EG and the CG were involved, and the data are presented in Table 2. For example, the calculation of the χ^2_{emp} criterion according to Equation (2), for EG2 and CG before the start of the experiment, where $n_1=61$ (EG1), $n_2=63$ (CG), is performed as follows (Equation 3). Similarly, all 5 possible results of pairwise comparisons of groups (experimental and control groups before the start) that are left are calculated. To automate the calculations, MS Excel was used. The calculation results for the experimental and control groups are shown in Table 3.

Having chosen the significance levels $\alpha \leq 0.01$ and $\alpha \leq 0.05$, the empirical values of the statistical criterion χ^2_{emp} in the studied groups with the critical value are compared (Equation 4), which is found in the table of critical values of the χ^2 criterion considering the degree of freedom $v=(k-1)(c-1)=(4-1)(2-1)=3$ (k – the number of categories of the sign: “high”, “sufficient”, “medium”, “low”; c – the number of subsections that are compared). In all 6 cases $\chi^2_{cr} > \chi^2_{exp}$ for significance level and $\alpha = 0.05$, therefore, the null

hypothesis is confirmed that, before the beginning of the formative stage of the pedagogical experiment, students of EG1, EG2, EG3, and CG had the same level of ICT competence development, coinciding at a significance level of 0.05, that is, they are statistically the same and belong to the same general population.

All the experiments performed in the studies involving human participants corresponded to the ethical standards of the institutional and national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

4. RESULTS AND DISCUSSION:

4.1 Analysis of the Results of the Survey among Teachers and Students

The frequency of the ICT use by teachers in the educational process is shown in Figure 1. It was found that 65.4% of teachers constantly use general-purpose software in their professional activities, 7.7% – often, 26.9% and 0% – sometimes and rarely, respectively. Hardware, basically, multimedia devices, is used by 50% of teachers in their classes. However, it should be noted that some of the respondents (40%) are also teachers of computer disciplines. That is, the percentage of the use of software and hardware in the educational process by teachers of non-computer disciplines will decrease by almost half. This is primarily due to the logistics problems, where teachers often need to use their laptops, mobile devices, sometimes portable projectors, and the like, in classrooms.

Teachers use communication tools (email, social networks, instant messaging, Facebook, Twitter) quite actively, in particular, 42.3% and 34.6% of teachers use them constantly and often, respectively. Cooperation/brainstorming tools (discussion forums, Wikis, Google Docs, Wikispaces, Mind Maps, Skype, and Google Drive) are constantly used by 15.4% of teachers, often – 42.3%, sometimes – 15.4%, rarely – 0%, and never – 26.9%. Cloud-based file storage/note-taking applications (Google Drive, Dropbox, Evernote) are constantly used by 34.6% of teachers, often – 15.4%, sometimes – 34.6%, rarely – 0%, and never – 15.4%.

However, to achieve the educational goals of the educational process and their professional development, more than 70% of teachers never,

rarely or sometimes use as follows: course management systems/content management systems/feed systems/learning management systems (WhiteBoard, Google Classroom, Moodle, and Sakai); mobile applications and devices (smartphones, tablets, iPad, and digital whiteboards); blogs and RSS feeds (Blogger, WordPress.); educational networks; free online courses/content (open training programs, open training resources, MOOCs, Prometheus, Udacity, and Edx); interactive student response systems or survey tools (synchronous tools, Plickers, Doodle, Learning Analytics, Socrative, Google Calendar, and the like); modeling, and educational games. The authors believe that the mediocre results of the ICT use in the educational process are associated with a rather large load on a teacher, the number of hours, and the number of students. For example, the total number of students, with whom a teacher works for a semester is as follows: 0-30 students – 8.3% of teachers, 30-60 students – 33.3%, 60-120 – 41.7%, 120 and more – 16.7%. The effectiveness of teaching using ICTs requires a large investment of a teachers time and intellectual resources to facilitate the in-depth training of each student, considering their individual characteristics, needs, motives, abilities, and the like.

The survey showed that the average value of the level of the ICT competence self-assessment is 4.33 out of 5. As the questionnaires' analysis shows, a sufficiently high score indicates a high level of competence of teachers in pedagogy and the subject they teach. Most teachers share the view that ICTs allow students to work together efficiently (76.9%), help optimize the time students spend on assignments, develop creativity and creative thinking, and deepen their knowledge of the discipline (92.3%).

The survey results based on the adapted methodology of UNESCO showed that absolutely all teachers have a computer and Internet access at home. Although 68.2% use it daily, 18.2% weekly, 9.1% monthly, and 4.5% of the respondents – once every 2-3 months. The last two indicators are typical for teachers aged 40 years and above. The question: "Do you use a computer at school?" was answered positively by 86.4% of chemistry teachers surveyed. The question "Do you have access to the Internet at school?" was answered positively by 71.8% of them.

The study showed that not all schools have the appropriate software and hardware. Thus, 12.9% of teachers have access to a

multimedia board. Moreover, they use it "always in the classroom, when they consider that the tool will help students learn". However, a multimedia system, which includes a projector, a projection screen, and a computer, can be used by 91.6% of chemistry teachers in the educational process. However, only 36.4% continuously use it in the classroom when they believe this tool will help students learn, and 50.0% only use it during open classes. This indicates a lack of desire and appropriate skills to use ICT for educational purposes.

In particular, 77% of teachers use ICT at a basic level (computer literacy). That is, they are capable of selecting and using ready-made training and game programs in their work, various web resources, simulators for practicing skills; organizing work in a computer classroom or using ICT tools that are available in other classrooms; applying ICTs to achieve the educational results that are implied by the educational standards, to conduct assessment activities, to implement thematic plans and traditional teaching methods; using ICT for current reporting and their professional development.

A total of 68% of teachers can deepen their knowledge and use them in educational activities. This level provides the ability to handle information, structure problems, and set tasks, to combine the use of chemistry software tools with the methods of personality-oriented educational work, with the students completing common educational projects; to use network resources for the implementation of group (joint) educational projects that allow students to work in concert, gain access to information and communicate with external experts in the analysis and solution of their chosen problems; the use of ICT to develop plans and evaluate their realization in the implementation of individual projects.

And only 55% of teachers believe that they are capable of producing new knowledge; that is, they can be as the exemplary students, masters of learning and creating new knowledge, who are constantly involved in educational experiments and innovations; produce new knowledge about the learning process and teaching methods together with colleagues and external experts; use network devices, digital resources, and electronic environments to create and support (anywhere, anytime) communities of people, who learn and generate knowledge together. One of the main conditions for effective ICT competence development is the creation of sustainable motivation for students educational and cognitive activities and their professional development. The

results of the study of the motivation for professional teaching of students, presented by the corresponding data in Table 1, allowed stating that there is a tendency to a decrease in the motivation when moving to senior courses.

Notably, in the interpretation of the methodology, three levels out of four are used: high (4), normal (3) (in this study, this is sufficient), and medium (2). Since it is believed that a low (1) level is not typical for students. However, as the study showed, when moving to senior courses, an insignificant percentage of students with a low level of motivation appears – these are students who either find it difficult to study in specialized subjects or they realize that they are studying in the wrong specialty, they have completely different professional interests and preferences. Therefore, it was decided to keep all four levels for analysis of the obtained empirical data.

The authors briefly describe the students by their level of motivation. A steady professional interest in learning characterizes students with a high and sufficient level of motivation, particularly in using ICT in the educational process by a chemistry teacher, self-development, and self-instruction. However, a high level also shows the students ability to improve professional activities, particularly through the study of new ICTs and the development of their software products. Regarding students with a medium level of motivation, they have a formed positive attitude and desire to acquire knowledge, skills, but are not able to systematically independently deepen and expand professional knowledge, in particular, with the use of ICT, and show educational and cognitive activity at the request of a teacher to demonstrate the results of their training activities. And, as noted above, students with a low level of motivation have a weak motivation to learn, often due to a lack of understanding of the educational material, the realization that they do not see themselves as chemistry teachers in the future, but have a positive attitude towards the use of ICT in teaching and personal development.

Regarding the actual motives for choosing a profession (answers 1–4 to question 1. “What prompted you to choose a profession?”), considering answers “rather yes than no” and “definitely yes”, the results are shown in (Figure 2): 29.5% of students are afraid to be out of a job in the future, students seeking to find themselves in the profession – 69.7%, some subjects are interesting – 76%, and it is interesting to study here – 70%. Regarding the motives of educational and cognitive activity (answers 5-8 to question 1) (Figure 3), answers “rather yes than no”,

“definitely yes”, to the questions are distributed as follows: “I study because it is required” – 39.6% of the respondents, “I study to keep up with my comrades (classmates)” – 26.7%, “I study because most of the subjects are necessary for the profession I chose” – 71%, “I believe that it is necessary to study all subjects” – 48%.

Among the motives that students mentioned when creating their portfolio, there are the following: love for children and the desire to help them learn chemistry using modern ICTs; chemistry and physics are your favorite school subjects; a dream from childhood to be a teacher; in-depth study of chemistry; the desire to devote himself/herself to teaching children; the opportunity to educate children and apply new methods so that they contribute to learning; the desire to raise and educate children; the chance to use your abilities; to improve your moral character and spiritual world; the satisfaction that work brings; communication opportunity; leadership by other people; changing the education system to develop the personality of a student; it is interesting to study at a university and the like.

The analysis of educational and work programs to prepare the recipients of bachelors degree in chemistry and questionnaires indicated the study of mainly chemical packages such as ChemOffice, ChemGraph. Moreover, the students specializing in Chemistry, who were enrolled in 2017-2018, were taught chemistry. They were offered to study computer-oriented systems for use in the educational process in the 3rd semester. The frequency of using heterogeneous ICTs in educational and cognitive activities by students is presented in Figure 4.

As shown in Figure 4, more than 50% of 2-4-year students rarely use ICT in their educational activities. Besides, the question “Are you ready to use multimedia, in particular, a multimedia board, in chemistry classes at school at this stage of training?” was answered positively by the students in the following percentage terms: 2nd year – 27.1% of students, 3rd year – 42.7%, and 4th year – 50%. The analysis of answers to the question: “Are you ready to use multimedia and create electronic educational resources (didactic and methodological materials) to ensure the educational process at school at this stage of training?” demonstrated that 28.6%, 37% and 50% of 2nd, 3rd and 4th-year students respectively gave a positive answer.

More than 97% of all students indicated that the use of diverse types of electronic

educational resources, multimedia, chemical systems in the educational process increases the intensity of studying educational material, helps to better understand and remember educational material, increases the activity of learning objects in the lesson, and helps to focus on educational material. Only 3% noted that this interferes with educational material perception, drains focus, and does not play any role. The students also noted that the most effective form of presentation of materials for educational and cognitive activities, in particular, when studying chemical systems, is as follows: fragments of material from academic disciplines (chemical and computer); electronic files designed for one or more practical exercises, which describe means for solving chemical problems and examples of their use; free work in the environment; open educational resources based on Moodle, Google Classroom.

4.2. Results of the Formative Stage of the Pedagogical Experiment

Since the students of the experimental groups EG1 and EG2 at the time of transition to the formative stage of the pedagogical experiment of the studied years did not differ in the level of ICT competence development. Therefore their data can be combined for further analysis in the group EG1_2. To identify the dynamics of changes in the levels of ICT competence, in particular, the general professional and subject-professional components of ICT, for the group EG1_2, three control cross-sections were conducted: at the stage of entrance control (Table 4), the weekend after studying the discipline "Multimedia Fundamentals" (Table 5) and at the stage of exit control after completing the study of the discipline "Packages of Chemical Programs" (Table 6) according to the updated methodology. In particular, the significance of the levels of ICT competence development according to all criteria for implementing the designed model and the methodology developed based on students of the EG1_2 group is given in Table 4.

According to the data, the technological component of ICT competence is the best-formed, which indicates appropriate training with ICT at the average user level. In particular, only 5.1% and 8.5% of students found a low level of development of this component of ICT competence. In contrast, at a sufficient and high level, together, the indicators of these criteria are 65.1% and 60.1%, respectively. This indicates the quality training of students in the courses "Information and Communication Technologies", "Informatics", "Fundamentals of the Internet",

which were taught to students in the first and second years of study. Also, a value-motivational criterion is well-formed and, as the ascertaining stage of the pedagogical experiment has shown, the main thing is to ensure stability, which will increase the indicator of this component at higher levels. Regarding the personality-reflexive criterion, the students under the applied diagnostic methods have the following results on the level of self-assessment and ability to self-development and self-instruction: high level – 3.3%, sufficient level – 26.3%, medium – 37.3%, and low – 33.1%. The authors believe that this depends on the personality of a student. Besides, students of the second year of study are not yet sufficiently adapted to the educational and cognitive activities at the university.

The second control cross-section was conducted after the students studied the academic discipline "Multimedia Fundamentals", the results of which are presented in Table 5. Since the methodological system of the discipline "Multimedia Fundamentals" was aimed at the development of a general professional component of ICT competence, the indicators of the relevant criteria have changed most of all. An important aspect is that the values of the levels of value-motivational and personality-reflexive criteria also increased. This is evidenced by rather high activity of the students during the execution of different types of tasks in the Moodle system at the laboratory and lecture classes.

The second control cross-section (after studying the course "Multimedia Fundamentals") showed that the percentage of students who have ICT competence at a high and sufficient level increased by 5.9% and 6.8%, respectively, at a medium level – only 1.7%, and the low one decreased by 11.0%. This is explained by the fact that the level of the subject-professional component of ICT competence increased at a high level only by 1.7% of students, at a sufficient level – by 3.9%, at medium – at 7.7%, but at a low level, it decreased by 4.3%. Then, as the value increased only at a sufficient level by 1.7%, and decreased at medium and low, respectively, by 2.6% and 0.9%. The growth of this component is since the preparation and development of didactic materials in mathematics, students had the opportunity to get acquainted with various types of experimental work, in particular methodological developments, for teaching chemistry, in which it is often proposed to solve problems using appropriate chemical systems, online services. Students who had a higher level of self-instruction and self-organization used these services to solve

chemical problems during the control cross-section after the 2nd stage of the formative experiment. Besides, most students first worked in the Moodle system and needed a longer adaptation to the conditions of changing educational activity when switching from full-time to an audience under the guidance of a teacher, online, when a student must organize his/her work for the relevant instructions.

The third control cross-section was conducted after the students studied the discipline "Packages of Chemical Programs", the results of which are presented in Table 6. Compared with the second stage, there is an increase in indicators by all criteria. However, the greatest increase is characteristic of such criteria as personal and general professional, since this stage of the formative experiment was aimed at the development of a subject-professional component of ICT competence.

Upon completion of the study of the disciplines "Multimedia Fundamentals" and "Packages of Chemical Programs", a questionnaire was conducted, which made it possible to determine the attitude of students to the learning process in the Moodle learning management system, the study of the corresponding software for the disciplines, and self-assessment of their ICT competence development. The students evaluated the disciplines, in particular, electronic training courses corresponding to them, according to criteria such as topic and curriculum, theoretical information, practical tasks, teacher competence, a variety of course tools, didactic and methodological support, software, hardware, relevance, essence and the innovativeness of the course, and the use of learning outcomes in the future. For example, the use of the obtained learning outcomes in the future after studying the disciplines "Multimedia Fundamentals" and "Packages of Chemical Programs" in the format of mixed learning for themselves was at a high level – 54.8% and 57.9%, at a sufficient level – 37.3% and 33.4%, at a medium – 7.9% and 8.7%, respectively. Table 7 presents the general results of forming the criteria for ICT competence: value-motivational, cognitive, operational-technological, and personality-reflexive.

The data obtained after the experiment confirmed the positive dynamics in the formation of ICT competence in the experimental group for each criterion. In particular, according to the motivational criterion, there was an increase in high and sufficient levels by 13.4% and 2.6%, in cognitive – by 21.1% and 19.7%, by operational-

technological – by 14.5% and 22.9%, and by personality-reflexive – by 16.5% and 21.2%, respectively. Moreover, the differences in the distribution of indicators of the levels of each criterion for ICT competence in the EG and the CG are different. This is confirmed at the significance level $\alpha=0.05$. In particular, χ^2_{emp} for the value-motivational criterion is 15.172, for the cognitive – 21.581, for the operational-technological – 17.719, for the personality-reflexive – 20.469. That is, in all cases $\chi^2_{\text{emp}} > \chi^2_{\text{crit}}$.

The comparison of empirical data on the levels of a generalized indicator of future chemistry teachers by ICT competence development in the EG and CG before and after completing the formative stage of the pedagogical experiment is shown in Figure 5. As can be seen from Figure 5, the formation of ICT competencies at high and sufficient levels for all EGs has improved qualitatively, and the indicators for the CGs have remained virtually unchanged. In particular, for the CG, the increase occurred at a high level of only 4.1%, and at a sufficient level – 6.7%. This only indicates an improvement in the quality of training students in forming the technological component of ICT competence, which is a prerequisite for the formation of a general professional (pedagogical) and subject-professional (chemical) component of ICT competence.

To identify the presence of differences in quantitative and qualitative indicators of the levels of ICT competence development in the EG and CG after the introduction of the model and experimental methods, the Pearson criterion χ^2 was used. It was established that after the experiment: the value of the Pearson criterion χ^2_{emp} for EG and CG is $\chi^2_{\text{em}} \approx 17.855 > 7.815 \approx \chi^2_{\text{crit}}$ at a significance level of 0.05. This means that the reliability of differences in ICT competence development in the EG and the CG after the experiment is 95%. It can be stated that the increase in the level of ICT competence development is due to the introduction of the developed model and convincingly testifies to its effectiveness in terms of future chemistry teachers by ICT competence development.

The variance analysis also confirmed the effectiveness of the developed model and the corresponding methodology for future chemistry teachers by ICT competence development. In particular, before the beginning of the formative stage of the pedagogical experiment, the coefficient of ICT competence development in the EG and CG was practically the same and amounted to 2.20 and 2.19, respectively, whereas

after the experiment – 2.94 and 2.48. The coefficient of ICT competence development is higher in EG, which indicates the effectiveness of the implemented model. The initial (before the start of the experiment) states of the experimental and control groups coincide, and the final (after the end of the experiment) states are different, which is mathematically confirmed using the Pearson criterion χ^2 and the variance analysis. Therefore, it can be stated that the effect of changes is due precisely to the testing of the designed model, the identified pedagogical conditions, and under the developed methodology.

5. CONCLUSIONS:

It was established that the acquisition of competencies, experience in open training systems, according to all respondents, is a prerequisite for the implementation of further effective educational, cognitive, and professional activities. The ascertaining stage of the pedagogical experiment established the need to choose and introduce the disciplines of mobile, computer, and cloud technologies for solving professionally-oriented problems. The bulk of the students surveyed noted the need to acquire knowledge, multimedia technologies, mobile, computer, and cloud chemical systems to solve professional problems and their further use in academic work.

1. The use of computers in chemistry lessons facilitates the development of the material, contributes to an increase in cognitive interest in chemistry, the development of the desire and ability to learn makes it possible to carry out an individual approach to teaching. It allows objectively assessing the knowledge of students. The learning process observations revealed that in lessons using ICTs, even “weak” students work more actively, are not distracted, and perform tasks with interest. Computer technology enhances perception, facilitates the assimilation and memorization of the material, and affects several information channels of the student at once. At the same time, students' interest in chemistry lessons increases.

2. The introduction of new information and communication technologies in the educational process makes it possible to activate the learning process, implement the ideas of developing education, and increase the lesson's pace, which significantly affects the motivational sphere of the educational process and its activity structure. But their use in the lesson should be thoughtful,

expedient, and competent.

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$$X = \frac{\sum_{i=1}^n x_i}{n} \quad (\text{Eq. 1})$$

$$\chi_{emp}^2 = \frac{1}{n_1 n_2} \sum_{i=1}^4 \frac{(n_1 Q_{2i} - n_2 Q_{1i})^2}{Q_{1i} + Q_{2i}} \quad (\text{Eq. 2})$$

$$\chi_{emp}^2 = \frac{1}{61 \cdot 63} \sum_{i=1}^4 \frac{(61 Q_{2i} - 63 Q_{1i})^2}{Q_{1i} + Q_{2i}} = \left(\frac{1}{61 \cdot 63} \frac{(61 \cdot 6 - 63 \cdot 6)^2}{6+6} + \frac{(61 \cdot 6 - 63 \cdot 6)^2}{6+6} + \frac{(61 \cdot 6 - 63 \cdot 6)^2}{6+6} + \frac{(61 \cdot 6 - 63 \cdot 6)^2}{6+6} \right) \approx 0.426286 \quad (\text{Eq. 3})$$

$$\chi_{emp}^2 = \begin{cases} 7.815 (\alpha \leq 0.05) \\ 11.345 (\alpha \leq 0.01) \end{cases} \quad (\text{Eq. 4})$$

Table 1. Dynamics of the Levels of Motivation for Vocational Training of 1-5-Year Students at the Ascertaining Stage of the Pedagogical Experiment

Motivation level	1 year		2 year		3 year		4 year		5 year	
	pers.	%	pers.	%	pers.	%	pers.	%	pers.	%
High	27	56.3	20	47.6	10	25.0	12	27.2	17	39.5
Sufficient	16	33.3	9	21.4	17	42.5	9	20.5	9	20.9
Medium	5	10.4	12	28.6	8	20.0	16	36.4	14	32.6
Low	0	0.0	1	2.4	5	12.5	7	15.9	3	7.0
Total	48	100.0	42	100.0	40	100.0	44	100.0	43	100.0

Table 2. Value of ICT Competence Development

Groups	Levels				Total
	High	Sufficient	Medium	Low	
EG1	Q ₁₁ =8	Q ₁₂ =16	Q ₁₃ =18	Q ₁₄ =15	n ₁ =57
EG2	Q ₂₁ =6	Q ₂₂ =17	Q ₂₃ =22	Q ₂₄ =16	n ₂ =61
EG3	Q ₃₁ =7	Q ₃₂ =18	Q ₃₃ =25	Q ₃₄ =20	n ₃ =70
CG	Q ₄₁ =6	Q ₄₂ =18	Q ₄₃ =24	Q ₄₄ =15	n ₄ =63

Table 3. Empirical Values of the χ^2 Criterion for the data in Table 2

	EG1	EG2	EG3	CG
EG1	0	1.029226	0.45807	1.924949
EG2	1.029226	0	1.427069	0.426286
EG3	0.45807	1.427069	0	1.974865
CG	1.924949	0.426186	1.974865	0

Table 4. Results of the First Control Cross-Section of ICT Competence Development for Students from EG1_2 before the Start of the Formative Stage of the Pedagogical Experiment

Criterion	Scale	Levels				Total
		High	Sufficient	Medium	Low	
Value-motivational (before)	persons	37	41	23	17	118
	%	31.4	34.7	19.5	14.4	100.0
Technological (before)	persons	29	48	35	6	118
	%	24.5	40.7	29.7	5.1	100.0
General professional (before)	persons	0	25	52	41	118
	%	0.0	21.2	44.1	34.7	100.0
Subject-professional (before)	persons	0	23	49	46	118
	%	0.0	19.5	41.5	39.0	100.0
Technological (after)	persons	23	48	37	10	118
	%	19.4	40.7	31.4	8.5	100.0
General professional (after)	persons	0	23	54	41	118
	%	0.0	19.5	45.8	34.7	100.0
Subject-professional (after)	persons	0	15	50	53	118
	%	0.0	12.7	42.4	44.9	100.0
Personality-reflexive (after)	persons	4	31	44	39	118
	%	3.3	26.3	37.3	33.1	100.0
ICT competence	persons	14	31	43	31	118
	%	10.2	27.1	36.4	26.3	100.0

Table 5. Results of the Second Control Cross-Section of ICT Competence Development for Students from EG1_2 at the Formative Stage of the Pedagogical Experiment

Criterion	Scale	Levels				Total
		High	Sufficient	Medium	Low	
Value-motivational (before)	persons	46	43	23	6	118
	%	39.0	36.4	19.5	5.1	100.0
Technological (before)	persons	31	54	29	4	118
	%	26.3	45.8	24.6	3.4	100.0
General professional (before)	persons	17	48	46	7	118
	%	14.4	40.7	39.0	5.9	100.0
Subject-professional (before)	persons	2	17	58	41	118
	%	1.7	14.4	49.2	34.7	100.0
Technological (after)	persons	25	52	33	8	118
	%	21.2	44.1	28.0	6.8	100.0
General professional (after)	persons	29	44	39	6	118
	%	24.6	37.3	33.1	5.1	100.0
Subject-professional (after)	persons	0	17	47	54	118
	%	0.0	14.4	39.8	45.8	100.0
Personality-reflexive (after)	persons	8	41	50	19	118
	%	6.8	34.7	42.4	16.1	100.0
ICT competence	persons	19	40	41	18	118
	%	16.1	33.9	34.7	15.3	100.0

Table 6. Results of the Third Control Cross-Section of ICT Competence Development for Students from EG1_2 of the Formative Stage of the Pedagogical Experiment

Criterion	Scale		Levels			Total
		High	Sufficient	Medium	Low	
Value-motivational (before)	persons	52	44	18	4	118
	%	44.1	37.3	15.2	3.4	100.0
Technological (before)	persons	43	56	19	0	118
	%	36.4	47.5	16.1	0.0	100.0
General professional (before)	persons	19	64	29	6	118
	%	16.1	54.2	24.6	5.1	100.0
Subject-professional (before)	persons	35	46	27	10	118
	%	29.7	39.0	22.9	8.5	100.0
Technological (after)	persons	31	62	23	2	118
	%	26.3	52.5	19.5	1.7	100.0
General professional (after)	persons	15	64	31	8	118
	%	12.7	54.2	26.3	6.8	100.0
Subject-professional (after)	persons	35	44	29	10	118
	%	29.7	37.3	24.6	8.5	100.0
Personality-reflexive (after)	persons	27	56	21	14	118
	%	22.9	47.5	17.8	11.9	100.0
ICT competence	persons	33	55	24	6	118
	%	28.0	46.6	20.3	5.1	100.0

Table 7. Results of ICT Competence Development Criteria for Future Chemistry Teachers (%)

Group	Levels	Criteria							
		Value-motivational		Cognitive		Operational-technological		Personality-reflexive	
		before	after	before	after	before	after	before	after
EG	High	31.3	44.7	8.0	27.1	6.4	22.9	8.0	24.5
	Sufficient	33.0	35.6	27.1	46.8	24.4	47.3	24.5	45.7
	Medium	19.7	15.4	37.8	21.3	39.9	23.4	36.1	18.1
	Low	16.0	4.3	27.1	4.8	29.3	6.4	31.4	11.7
CG	High	19.0	20.3	8.0	11.7	8.5	13.6	9.5	11.9
	Sufficient	46.1	42.4	19.0	30.0	22.5	28.8	25.4	28.8
	Medium	25.4	23.7	47.6	43.3	35.3	37.3	49.2	45.7
	Low	9.5	13.6	25.4	15.0	33.7	20.3	15.9	13.6

Figure 1. Use of ICT in the Educational Process by Teachers (%)

Figure 2. Future Chemistry Teachers' Motives for Choosing the Profession (%)

■ definitely yes ■ rather yes than no ■ it doesn't matter ■ rather no than yes ■ rather no

Figure 3. Motives of Educational and Cognitive Activities of Students (%)

Figure 4. Frequency of Students using ICT in Educational Activities (%)

Figure 5. Levels of Future Chemistry Teachers' ICT Competence Development from the EG and CG before and after the Completion of the Formative Stage of the Pedagogical Experiment (%)

APPENDIX 1.

Survey Questions for Teachers:

1. How often do you use ICT to prepare for classes?
2. How often do you encourage/teach students to create products using ICT?
3. How often do you aim students at using ICT during classes?
4. How often do you use ICT to give class recommendations/instructions?
5. How often do you use general-purpose professional software?
6. How often do you use communication tools (email, social media, instant text messaging, Facebook, Twitter.)?
7. How often do you use cooperation/brainstorming tools (discussion forums, Wikis, Google Docs, Wikispaces, Mind Maps, Skype, Google Drive)?
8. How often do you use cloud-based file storage/note-taking applications (Google Drive, Dropbox, Evernote.)?
9. How often do you use course management systems/content management systems/feed systems/learning management systems, mobile applications and devices, blogs and RSS feeds, educational networks, interactive student response systems or survey tools, modeling and educational games to achieve the educational goals of the educational process and their professional development?
10. Do ICTs allow students to work together efficiently, in your opinion?
11. Do ICTs help optimize the time students spend on assignments, develop creativity and creative thinking, and deepen their knowledge of the discipline, in your opinion?
12. How often do you use the Internet?
13. Do you use a computer at school?
14. Do you have access to the Internet at school?
15. How often do you use multimedia equipment?
16. What is your ICT level?
17. Are you able to deepen your knowledge and use it in educational activities?
18. Are you capable of producing new knowledge?

Survey Questions for Students:

1. What prompted you to choose a profession?
2. Are you ready to use multimedia, in particular, a multimedia board, in chemistry classes at school at this stage of training?
3. Are you ready to use multimedia and create electronic educational resources (didactic and methodological materials) to ensure the educational process at school at this stage of training?
4. How often do you use ICT in educational activities?
5. Do you agree that using diverse types of electronic educational resources, multimedia, chemical systems in the educational process increases the intensity of studying educational material, helps to better understand and remember educational material, increases the activity of learning objects in the lesson, and helps to focus on educational material?
6. What is the most effective form of presentation of materials for educational and cognitive activities, in your opinion?