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Training future computer science teachers in the context of digitalisation based on the "History of informatics" course

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Abstract

The relevance of the study is determined by the fact that the formation of the principles of teaching the use of information technologies needs to be laid in the learning process. The aim is to study the working conditions of a modern computer science teacher and to determine the main directions of their training. The method of analysis made it possible to identify the discrepancy between the realities of the work of a computer science teacher at school and the training system at a university. The paper shows that digitalisation of learning is determined not only by the use of certain digital products but also by the formation of a digital learning environment. The practical significance is determined by the possibilities of a structural understanding of teaching future computer science teachers when using a combination of information technologies with the need to use them in practice in a modern school.

Keywords: information and communication technologies (ICT); information educational environment; pedagogical activity; professional competence.

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1.Introduction

The problem of using information and communication technologies at school is of particular interest, because, as practice shows, today the students learn the skills of working with specific software tools. However, in the modern world, technologies are changing so rapidly that it is not clear whether students will need this specific knowledge and skills in real life outside of school. According to scientists, this fact conditions the need to move to a competency-based approach (Bakhmat, 2020). For example, when teaching how to represent certain information data for various segments of the population, then the emphasis shifts to ways of presenting the material, and software products act as tools. The student must have a good idea of the final goal, understand how a computer can solve various problems, and use various technical means. The speed of informatisation of society and the spread of information and communication technologies (ICT) implies new approaches to the organisation of the educational process, in particular, in general, educational institutions. Information support makes it possible for a person to master large volumes of information, thereby creating new knowledge and gradually moving to a new type of society – an information society. Such society requires changes in the content, methods and organisational forms of educational work, which necessitates the development of information and educational environment for a general educational institution. This phenomenon, in turn, contributes to an increase in the efficiency and flexibility of education, modernises it and brings it in line with international standards. For the formation of students' skills necessary for life in an information society, it is important to integrate digital technologies into all components of the educational process and the competent use of ICT. That is why it is of particular importance to build an information educational environment for a general education institution, the main functions of which for a computer science teacher are: preparation for classes, self-education, generalisation of professional experience, training organisation, communication with parents (Molnar & Ryabets, 2019).

In the scientific literature, there are various terms to designate the educational environment of an academic institution, namely, information educational environment, information space, information environment (Abramov & Sokolov, 2017). The concept of "environment personalisation" is often used, which presupposes a certain assignment by the subject's consciousness of a certain part of the environment as his I. The information space of a general educational institution is defined as an adaptation model of regional and national information spaces, which is considered as a structured set of resources and technologies based on common educational and technological standards (Nos, 2019). An information educational environment is a systemically organised set of information, technical, educational and methodological support, inextricably linked with a person as a subject of the educational process (Perminov et al., 2019; Burns et al., 2020). The information environment is perceived as a part of the information space, the information environment closest to the individual, the set of conditions in which his activities directly take place. It is proposed to consider the information educational environment as a pedagogical system and its support, that is, financial and economic, material and technical, regulatory and marketing subsystem, as well as a management subsystem (Zinchenko, 2020).

Technically, the information educational environment is built by integrating information on traditional and electronic media, computer and telecommunication technologies, virtual libraries, distributed databases, academic and methodological complex and an expanded didactic apparatus. In the authors' opinion, the concept of "information educational environment" most fully conveys its content, so we will use this definition. Thus, the information educational environment is a system created based on modern educational, methodological, information and technical means, which consists of functional educational subsystems that keep records of participants in the educational process. Hence, the aim of the research is to study the working conditions of a modern computer science teacher and, accordingly, to determine the main directions of training in the field of ICT for students, future teachers of computer science.

2. Literature Review

The interaction of the subject with the environment is considered in three dimensions: subject-object, subject-subject and the development of the aggregate subject (when the system of relations "subject-environment" acts as an integral subject, while implementing the principles of development and selfdevelopment) (Gao, 2012). Today there is a great need for the development and implementation of the information environment of academic institutions, which would enable students to acquire the necessary skill sets more effectively, help teachers in organising and introducing new educational teaching methods, and meet the needs of parents to monitor the success of their children's education (Zhao & Qian, 2018). At the same time, some scientists note certain inconveniences associated with the use of learning environments and applied software tools: using ready-made learning environments, the teacher is limited to the means of learning activities that are embedded in them, and is forced to use the arsenal of visual, lecture materials, laboratory practicals, auxiliary materials included by the developers (Qi et al., 2009). This is inconvenient as the teacher "adjusts" to the environment (Zhao & Wang, 2013). The practice of software development has shown that a future teacher himself can create a software tool that is not inferior in terms of its performance to others on the market (Ji & Shen, 2009).

Many scientists have dealt with the problems of creating information educational environments for educational institutions, however, main attention was paid to the creation of an information educational environment for higher educational institutions, and the role of educational (quasi-professional) activity in the formation of skills necessary for future computer science teachers was also insufficiently defined (Qi, 2009). Consequently, in the process of professional training of future teachers, it is necessary to develop ICT competencies for successful professional activities, to provide the necessary knowledge in the development of the educational information environment, and to improve or modernise its individual elements (Li et al., 2009).

The formation of the necessary competencies of future computer science teachers is not possible without modelling the real situations of the future professional activity, that is, the creative nature of the quasi-professional activity, in particular when developing and modernising both the educational information environment and its individual elements for satisfying the requirements (Aiqun, 2018). The main goals of creating an information educational environment are associated with providing fundamentally new opportunities for cognitive creative human activity (Yan & Fangqin, 2019). This can be achieved through the use of modern information and technical equipment for the main educational activities: learning, pedagogical, research, organisational, managerial and examination activities in education (Shen & Yang, 2010).

The advantages of the information educational environment include a "paperless" version of the school with broad functionality, the integration of traditional and distance learning forms, mobility, the formation of 21st-century skill set, which include the intuitive mastering of computer science and computing, electronic devices, mobile devices (Duan & Liu, 2010). Typological signs of the information educational environment (Wang & Xing, 2011):

1) The educational environment of any level is a complex composite object of a systemic nature.

2) The integrity of the educational environment is synonymous with achieving a systemic effect, which is understood as the implementation of the comprehensive goal of teaching and upbringing at the level of lifelong education.

3) The educational environment functions as a certain social community that develops the totality of human relations in the context of the broad socio-cultural and ideological adaptation of a person to the world and vice versa.

4) The educational environment has a wide range of modality that forms a variety of types of local environments of different, sometimes mutually exclusive qualities.

5) In goal-oriented planning, educational environments give a total educational effect of both positive and negative characteristics, and the vector of value orientations is determined by the target settings of the general content of the educational process.

6) The educational environment acts not only as a condition but also as a means of teaching and upbringing.

7) The educational environment is a process of dialectical interaction of social, spatial and subject, psychological and didactic components that form a coordinate system of leading conditions, influences pedagogical goals.

8) The educational environment forms a substrate for individualised activity, a transition from an educational situation to life.

9) The educational environment exists as a certain social community that develops the totality of human relations in the context of a broad sociocultural worldview adaptation of a person to the world, and vice versa (Hu & Zhang, 2012).

One of the most modern teaching methods with the active use of information technology, the effectiveness of which has already been tested abroad, is blended learning (Teng, 2013). Due to the lack of material and technical support and the difficulty of transitioning to modern education through the ingrained and conservative nature of traditional textbook teaching, blended learning is rarely used in secondary and higher educational institutions (Xu et al., 2011). It is the educational information environment of an institution that creates conditions for the systematic use of new educational technologies, including blended learning, flipped classroom and others (Shang et al., 2014).

According to the Clayton Christensen Institute for Disruptive Innovation, blended learning is a formal educational program in which a student studying (Li & Lu, 2017): at least in part through online learning, with a certain element of personal control over the time, place, path and/or pace of learning; in the classroom during a lesson supervised by a teacher; provided that all stages along the learning path of each student within the course or subject are connected in order to provide a blended learning experience. The rapid development of digital technologies significantly affects the change in pedagogical approaches and principles (Wang, 2020). Teachers should be mentors for students and generators of knowledge, constantly engage in innovations and pedagogical experiments (Li, 2020). The teacher’s use of information and communication technologies (ICT) is characterised by a knowledge creation approach to the teaching process (Teng, 2014). That is, ICT should serve the teacher as a means of developing student’s skills for acquiring knowledge and developing critical thinking.

3. Materials and Methods

A modern computer science teacher has to solve a wide range of various problems, often not directly related to the educational process. In most schools, there is no special staff obliged to maintain computers, printers, projectors and other technical devices, lay a local network, solve organisational issues on access to the Internet, create and maintain an educational institution’s website, etc. It is a teacher who partially or completely performs the above and other tasks. The leading, and often the only, ICT specialist in the school is the computer science teacher. The range of his duties and requirements for his skills has been constantly expanding in recent years.

According to the study design, at the first stage (2019-2020), several surveys were conducted, which made it possible to determine the level of professional competence in teachers, the range of responsibilities for the development of the information educational environment of general education institutions, typical difficulties that emerged in the early years of work. The survey was performed using Google Forms, the purpose of which was to identify the actual range of responsibilities and work characteristics of a modern computer science teacher. Note that the invitation to take the survey was sent twice with an interval of four months to the e-mail addresses of teachers of general education institutions. 34 respondents took part in the survey. The low level of participation in the survey indicates the passive position of the majority of teachers, which contradicts the requirements for the representatives of this profession.

For the next stage – the ascertaining pedagogical experiment, the experimental and control groups of students (134 and 130 people) were determined with approximately the same distribution by the levels of certain criteria (Table 1). The results of surveys and an assessment of the level of professional competence development in future computer science teachers confirmed the relevance of the study and made it possible to draw the following conclusions: the overwhelming majority of students have a low level of the studied phenomenon both in terms of the average indicator and in the context of individual criteria, which significantly affects the quality of teaching practice and further professional activity.

Table 1. Development of professional competence in future computer science teachers (results of the ascertaining stage of the experiment (%))

Criteria	High level		Average level		Low level	
	CG	EG	CG	EG	CG	EG
Motivational	1.4	1.5	31.8	32.6	66.8	65.9
Cognitive	1.2	1.3	16.3	16.4	82.5	82.3
Operational and pragmatic	1.9	1.8	15.2	15.8	82.9	82.4
Communicative	1.4	1.6	24.8	25.6	73.8	72.8
Personality	1.6	1.7	14.8	14.9	83.6	83.4
Averaged	1.5	1.58	20.58	21.06	77.92	77.36

At the formative stage of the pedagogical experiment, a comparative analysis of the student's achievements in the control and experimental groups (the author's developments were used in the process of teaching) was carried out. Following the goal of the formative stage of the experiment, an experimental test of the effectiveness of the developed model of professional competence formation in quasi-professional activities and the developed forms and methods was carried out, in particular on the material of the course "History of informatics". Based on the results of the formative stage of the experiment, the effectiveness of educational activity in the control and experimental groups was determined. In the 2019-2020 academic year, 264 students studied the discipline "History of informatics" developed based on the proposed methodological system. For statistical confirmation of the study, the Pearson criterion (χ^2) will be used, the value of which will be calculated by the formula using the classic notation:

$$\chi^2_{emp} = \frac{1}{n_1 n_2} \sum_{i=1}^{3} \frac{(n_1 Q_{2i} - n_2 Q_{1i})^2}{Q_{2i} + Q_{1i}} \quad (1)$$

where n_1 and n_2 – volumes of the first and second samples; Q_{11}, Q_{12}, Q_{13} – the number of objects of the first sample that fell into the category of state of the studied property (in our case, to groups of students with high, medium and low levels of formed competencies), in accordance with Q_{21}, Q_{22}, Q_{23} – the number of objects of the second sample that fell into the category of state of the studied property (for groups of students with high, medium and low levels of formed competencies).

Before starting the experiment, at the ascertaining stage, we put forward the null (H_0) and alternative (H_1) hypotheses:

– H_0: The level of formedness of professional competence of future teachers in quasi-professional activities has not changed significantly.

– H_1: The level of formedness of the professional competence of future teachers in quasi-professional activities has undergone significant qualitative changes.

If the null hypothesis is confirmed in the course of the research, this will indicate insignificant quantitative differences in the levels of professional competence of future computer science teachers in quasi-professional activities before and after the experiment. And this, in turn, indicates the ineffectiveness of the applied methodology. In case of confirmation of an alternative (experimental) hypothesis about significant quantitative differences in the levels of professional competence at the beginning and the end of the experiment, we will receive mathematical confirmation of the effectiveness of the methodology developed by the authors during the thesis research. To calculate the value of the statistic χ^2_{ex}, we introduce the designations that correspond to those used in the formula to calculate the value of the Pearson criterion and carry out the necessary calculations. For this, we will compose an auxiliary Table 2. Substituting the values of the corresponding variables into the formula for calculating the value of the Pearson criterion, we obtain χ^2_{ex} for each criterion of the professional competence of future computer science teachers in quasi-professional activities.

Table 2. Auxiliary table for calculating the value of χ^2_{ex} when comparing the distributions of future teachers of the experimental and control groups by the levels of professional competence in quasi-professional activities at the beginning of the experiment

Sample	Number of teachers	Number of teachers with a high level	Number of teachers with an average level	Number of teachers with a low level
		Motivational criterion		
EG	n_1=134	Q_{11}=2	Q_{12}=44	Q_{13}=88
CG	n_2=130	Q_{21}=2	Q_{22}=41	Q_{23}=87
Total	N=264	$Q_{11}+Q_{21}$=4	$Q_{12}+Q_{22}$=85	$Q_{13}+Q_{23}$=175
		Cognitive criterion		
EG	n_1=134	Q_{11}=2	Q_{12}=22	Q_{13}=110
CG	n_2=130	Q_{21}=2	Q_{22}=21	Q_{23}=107
Total	N=264	$Q_{11}+Q_{21}$=4	$Q_{12}+Q_{22}$=43	$Q_{13}+Q_{23}$=217
		Communicative criterion		
EG	n_1=134	Q_{11}=2	Q_{12}=34	Q_{13}=98
CG	n_2=130	Q_{21}=2	Q_{22}=32	Q_{23}=96
Total	N=264	$Q_{11}+Q_{21}$=4	$Q_{12}+Q_{22}$=66	$Q_{13}+Q_{23}$=194
		Operational and pragmatic criterion		
EG	n_1=134	Q_{11}=2	Q_{12}=21	Q_{13}=110
CG	n_2=130	Q_{21}=2	Q_{22}=20	Q_{23}=108
Total	N=264	$Q_{11}+Q_{21}$=4	$Q_{12}+Q_{22}$=41	$Q_{13}+Q_{23}$=218
		Personality criterion		
EG	n_1=134	Q_{11}=2	Q_{12}=20	Q_{13}=112
CG	n_2=130	Q_{21}=2	Q_{22}=19	Q_{23}=109
Total	N=264	$Q_{11}+Q_{21}$=4	$Q_{12}+Q_{22}$=39	$Q_{13}+Q_{23}$=221

We will determine the nature of shifts in the indicators of motivational, cognitive, communicative, operational and pragmatic, and personality criteria for the formation of the professional competence based on comparisons of the distributions of teachers in the experimental and control groups. According to the indicators of these criteria after the formative experiment, the authors believe that the differences in distributions occurred due to the degree of observance of all conditions for the implementation of the professional competence formation model in the groups trained according to the developed element of the methodological system. According to certain characteristics of the indicators of each criterion for the formation of professional competence, a teacher could fall into one of three categories: a group with a low, medium, or high level of the indicators and corresponding criteria. To calculate the value of statistic χ^2_{ex}, after the experiment, we introduce the designations that correspond to those used in the formula for calculating the value of the Pearson criterion and make the necessary calculations. For this, we will draw up an auxiliary Table 3.

Table 3. Auxiliary table for calculating the value of χ^2_{ex} when comparing the distributions of teachers in the experimental and control groups by the levels of professional competence formedness in quasi-professional activities after the experiment

Sample	Number of teachers	Number of teachers with a high level	Number of teachers with an average level	Number of teachers with a low level
		Motivational criterion		
EG	n_1=134	Q_{11}=16	Q_{12}=99	Q_{13}=19
CG	n_2=130	Q_{21}=7	Q_{22}=81	Q_{23}=42
Total	N=264	$Q_{11}+Q_{21}$=23	$Q_{12}+Q_{22}$=180	$Q_{13}+Q_{23}$=61
		Cognitive criterion		
EG	n_1=134	Q_{11}=13	Q_{12}=93	Q_{13}=28
CG	n_2=130	Q_{21}=6	Q_{22}=75	Q_{23}=49
Total	N=264	$Q_{11}+Q_{21}$=19	$Q_{12}+Q_{22}$=168	$Q_{13}+Q_{23}$=77
		Communicative criterion		

EG	$n_1=134$	$Q_{11}=16$	$Q_{12}=90$	$Q_{13}=28$
CG	$n_2=130$	$Q_{21}=10$	$Q_{22}=75$	$Q_{23}=50$
Total	N=264	$Q_{11}+Q_{21}=26$	$Q_{12}+Q_{22}=168$	$Q_{13}+Q_{23}=78$
Operational and pragmatic criterion				
EG	$n_1=134$	$Q_{11}=23$	$Q_{12}=102$	$Q_{13}=9$
CG	$n_2=130$	$Q_{21}=13$	$Q_{22}=83$	$Q_{23}=34$
Total	N=264	$Q_{11}+Q_{21}=4$	$Q_{12}+Q_{22}=185$	$Q_{13}+Q_{23}=43$
Personality criterion				
EG	$n_1=134$	$Q_{11}=17$	$Q_{12}=90$	$Q_{13}=27$
CG	$n_2=130$	$Q_{21}=11$	$Q_{22}=73$	$Q_{23}=46$
Total	N=264	$Q_{11}+Q_{21}=28$	$Q_{12}+Q_{22}=163$	$Q_{13}+Q_{23}=73$

The analysis made it possible to identify the discrepancy between the realities of the work of a computer science teacher at school and the training system at a university, the results of the stages described above are presented in the next section.

4. Results and Discussion

Our anonymous survey among future teachers made it possible to determine that Computer science in schools is often taught not by computer science teachers. Thus, a survey among the respondents revealed that only 57% are educated teachers of Mathematics or Physics with a specialisation in Computer Science, and 43% are representatives of other professions, in particular, a programming engineer, a Handicraft teacher, a primary school teacher, a communication engineer, a teacher of Geography and Biology, economist. From the authors' standpoint, this is due to the interdisciplinary, integrative nature of the subject, as well as the wide range of responsibilities for the creation and support of the information educational environment of the educational institution. The overwhelming majority of representatives of other professions are in the 36-45 age group. The distribution of respondents by age and work experience as a computer science teacher is presented in Figure 1. All teachers with less than 3 years of experience, except for one person, are 20-25 years old, that is, young teachers who work in their specialty. Based on the results of the survey, it was established that all of them acquired a profession "Mathematics teacher. Specialisation: Computer Science".

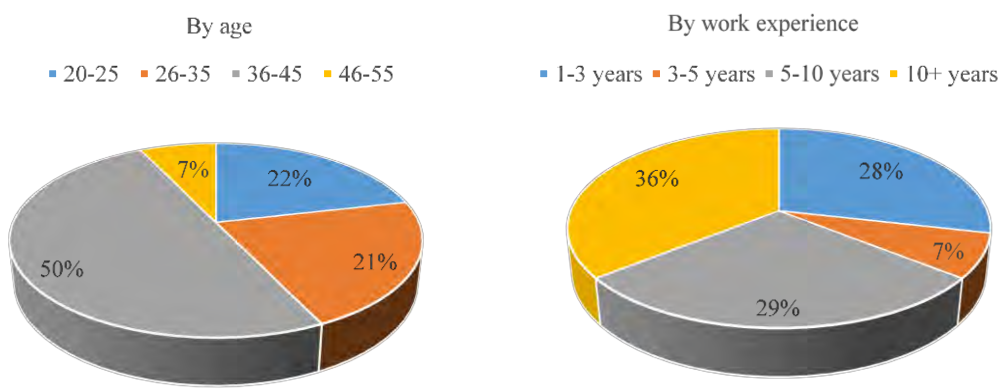

Figure 1. Distribution of teachers taking part in the survey

Analysing the technical equipment of schools, we note that within the framework of the study, we did not set ourselves the goal of determining how modern or outdated computer technology is. The development of support for the information educational environment of general education schools, from our point of view, depends primarily on the beliefs of the leadership of educational institutions and other authorities. We have not found the dependence of the number of computers on the number of students or the type of educational institution. A fragment of the survey results is shown in Table 4, which presents several educational institutions with a comparable number of students.

Table 4. Fragment of the survey results to determine the technical equipment of the school

Type of educational institution	Number				Availability of technical means in a computer science classroom					
	Students at school	Computer science teachers	Computers in classrooms	Computers in the administration	The Internet	Video projector	Interactive whiteboard	Printer	Speakers	Microphone
General education school	65	1	5	3	+	+	-	+	+	
General education school	84	1	10	2	+	-	-	+	+	
General education school	127	2	12	2	+	+	-	+	+	
General education school	140	2	7	1	+	+	-	+	+	
Educational complex	675	2	10	5	+	+	-	-	+	
Lyceum	700	7	61	28	+	+	+	-	-	
Gymnasium	1125	2	26	10	+	+	+	+	-	
General education school	1154	3	28	12	+	+	-	+	-	
Specialist school	1356	2	30	16	+	+	+	+	-	

It should be noted that only one educational institution has the opportunity to use robotic toys in computer science lessons, and 7% of teachers noted that they would like to have such an opportunity. Analysing professional experience, we found that 25% of teachers with work experience of up to three years have no experience in preparing students for any Olympiads, competitions, tournaments. Figure 2 shows the experiences of all respondents in preparing students for different types of computer science competitions.

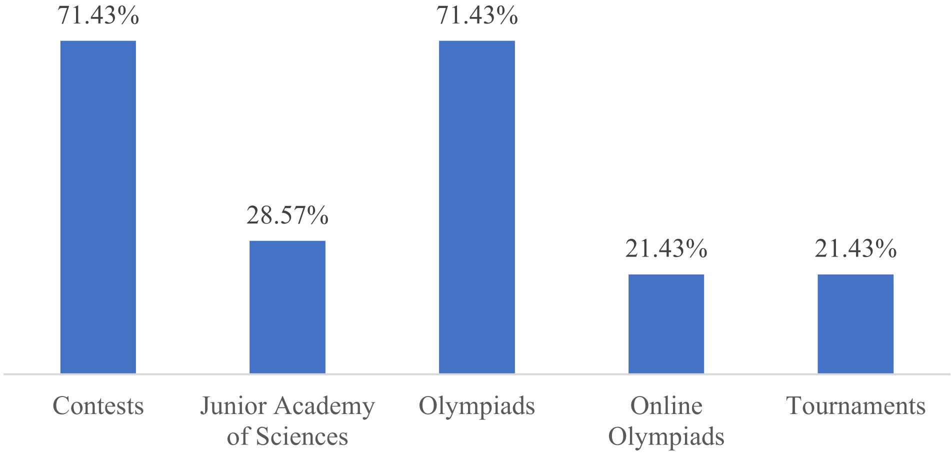

Figure 2. The experience of teachers in preparing students for different types of computer science competitions

We also found that 21% of teachers do not conduct any extracurricular activities. It turned out that they all have less than three years of work experience. All other respondents regularly hold events to increase interest in the study of computer science and programming, to deepen the knowledge of students. Among the answers to this question, there are the following types of extracurricular activities: computer science circle (64%), thematic weeks on informatics (43%), an educational complex based on a computer science classroom (43%), including safe behaviour in networks, etc. Note also that 93% of informatics teachers have profiles in social media, 29% have their website, 43% have a blog, and 14% of respondents are regular users of professional networks and forums on the relevant topic.

To identify the range of responsibilities of a computer science teacher not directly related to the educational process, we proposed questions in the form of a grid. Based on the previous survey of teachers and their own experience, a list of situations of use and implementation of ICT that teachers face in a general education institution was proposed. Note that the list is incomplete since the authors have tried to include the most typical situations. All teachers who took part in the survey, regardless of education and work experience, advise and help colleagues. The study confirmed the hypothesis that it is the computer science teacher who overwhelmingly performs a wide range of tasks, in particular, to create an information educational environment for a general education institution, from solving strategic issues to servicing technical teaching aids. Realising the importance of information infrastructure development, the management of some educational institutions finds an opportunity to maintain a special employee. Figure 3 provides a comparative analysis of the distribution of responsibilities between a computer science teacher and a specialist staff member since the other proposed options ("school administration", "parents/invited specialists" and "nobody is involved") were rare.

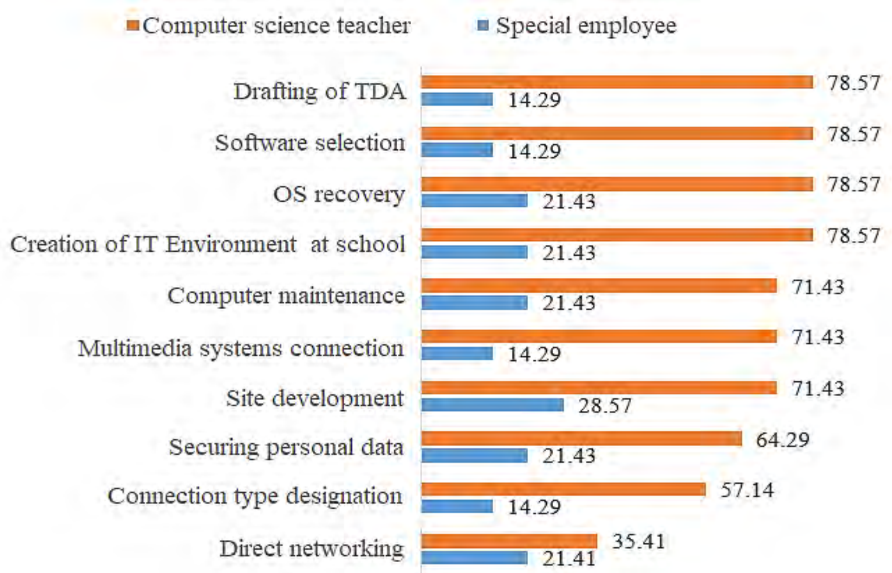

Figure 3. Distribution of responsibilities for the tasks of creating and maintaining the information educational environment of the school

In 43% of schools, the administration forms applications and submissions for the purchase of equipment without involving computer science teachers, but in 50% of schools, this task is the teacher's area of responsibility. An interesting fact was that the answer options "Special employee" or "Invited persons" were chosen by teachers of schools in which a high percentage of computers are in the administrative part of the school (at least 33% of computers in classrooms). The frequency of choosing these answer options is not influenced by the number of students in the school, the number of informatics teachers, the type of educational institution. In 7.14% of schools, parents or specialists from relevant companies are involved to maintain computers in the administrative part of the school, determine the type and equipment for connecting computers to the network. Also, a part of teachers (up to 15%) notes that no one in their educational institutions is involved in organising the protection of personal data in electronic form, creating a network in an educational institution, choosing and installing software for classrooms.

Besides, the analysis showed that the range of duties that a computer science teacher performs significantly exceeds functional duties and is not directly related to the educational process. Among the activities that are fully or partially performed by teachers of informatics, respondents noted the following: creation and support of the website of an educational institution; deployment of support systems for educational activities, management of educational content, file sharing, etc. lining of a local network;

selection, installation and configuration of software; installation and maintenance of technical training aids, consulting colleagues, etc. At the same time, the study made it possible to determine that only about half of the respondents who took part in the survey are teachers of computer science by education. From the authors’ point of view, the indicated phenomenon can be explained by the relatively short time of the existence of “Computer science” as an academic subject and the corresponding specialisation for teachers, as well as the outstanding integration and interdisciplinary nature of this area. After listening to the course “History of informatics” and based on the results of pedagogical practice, we surveyed students: whether they plan to work at school in the main specialty and the specialisation “Computer science”. Thus, 19.8% of respondents do not plan to work as a teacher, 51.6% want to work in their main specialty and 28.6% of respondents in the field of specialisation.

Table 5 shows the values of the criterion χ^2_{ex}, calculated from the data of the experiment (Table 2) (χ^2_{ex}) by the motivational, cognitive, communicative, operational and pragmatic, and personality criteria for the formation of professional competence of future teachers in quasi-professional activity in accordance with the tabular values of (χ^2_{cr}). Comparison of the values of the above-mentioned components gives grounds for the conclusion that the differences in the distributions of teachers from the experimental and control groups by the levels of all five criteria are not statistically reliable.

Table 5. The value of the test statistics χ^2_{ex} when comparing the distributions of future teachers from the experimental and control groups by the levels of the professional competence formedness at the beginning of the experiment

Criteria of readiness	Statistical values of the criterion χ^2			
	Sample type	χ^2_{ex}	χ^2_{cr}	**Output**
Motivational criterion	EG	0.05	5.99	$\chi^2_{ex}<\chi^2_{cr}$
Cognitive criterion	EG CG	0.004	5.99	$\chi^2_{ex}<\chi^2_{cr}$
Communicative criterion	EG CG	0.02	5.99	$\chi^2_{ex}<\chi^2_{cr}$
Operational and pragmatic criterion	EG CG	0.012	5.99	$\chi^2_{ex}<\chi^2_{cr}$
Personality criterion	EG CG	0.05	5.99	$\chi^2_{ex}<\chi^2_{cr}$
Formedness	Arithmetic mean	0.0014	5.99	$\chi^2_{ex}<\chi^2_{cr}$

Thus, the results obtained give grounds for asserting that the selected groups of teachers in the experimental and control groups are equivalent according to the specified criteria. The analysis of the results showed a significant increase in the quantitative indicators of the criteria in the experimental group, but in the control group, the changes were insignificant. The results obtained are presented in Table 6. The results of the final survey of future teachers indicate their understanding of the role of quasi-professional activity in the formation of professional competence.

Table 6. The results of the control stage of the experiment (in percent)

Criteria	High level		Average level		Low level	
	CG	**EG**	**CG**	**EG**	**CG**	**EG**
Motivational	5.6	11.6	62	74	32.4	14.4
Cognitive	4.6	9.8	58	69.1	37.4	21.1
Operational and pragmatic	9.8	17.2	64.2	76.1	26	6.7
Communicative	7.6	11.9	54	67.2	38.4	20.9
Personality	8.5	12.4	56	67.5	35.5	20.1
Average	6.6	12.8	61.4	73.1	32	14.1

The general sample of students was 264 people. Despite the positive trend, which is manifested in the growth of indicators of the levels of educational achievements and personal complexes among students in the experimental and control groups, the qualitative results are much higher. Thus, at a high level, the biggest increase was found for the operational and pragmatic criterion (9.8% in the control groups and 17.2% in the experimental and 64.2% and 76.1%, respectively, for the average level) (Figure 4). According to the personality criterion at a high level, in the experimental groups the difference is 12.4%, and in the control groups – 8.5% and on average 56% and 67.5%, respectively (Figure 5).

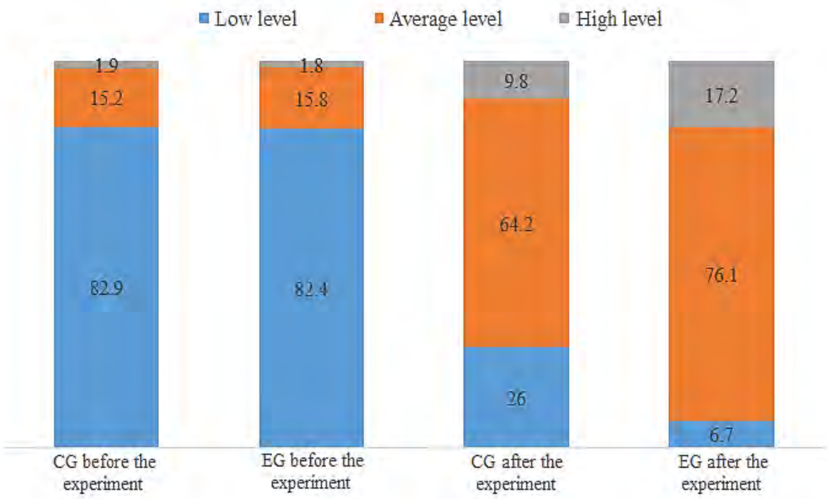

Figure 4. Results of a comparative analysis of the ascertaining and control stages of the experiment according to the operational and pragmatic criterion

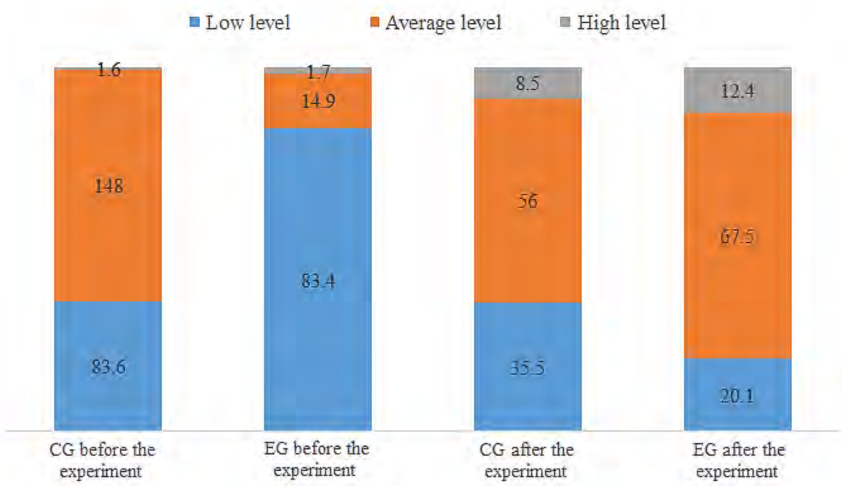

Figure 5. The results of a comparative analysis of the ascertaining and control stages of the experiment according to the personality criterion

According to the communicative criterion at a high level in the experimental group, the difference is 11.9% compared to 7.6% in the control (Figure 6), on average 67.2% and 54.0%, respectively. According to the motivational criterion at a high level, the increase in the experimental groups is 11.6%, in the control – 5.6% (Figure 7), and on average 62.0% and 74.0%, respectively.

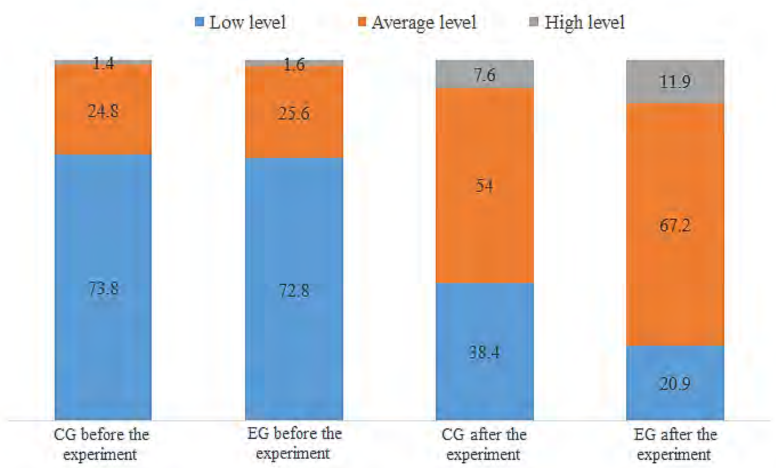

Figure 6. Results of a comparative analysis of the ascertaining and control stages of the experiment according to the communicative criterion

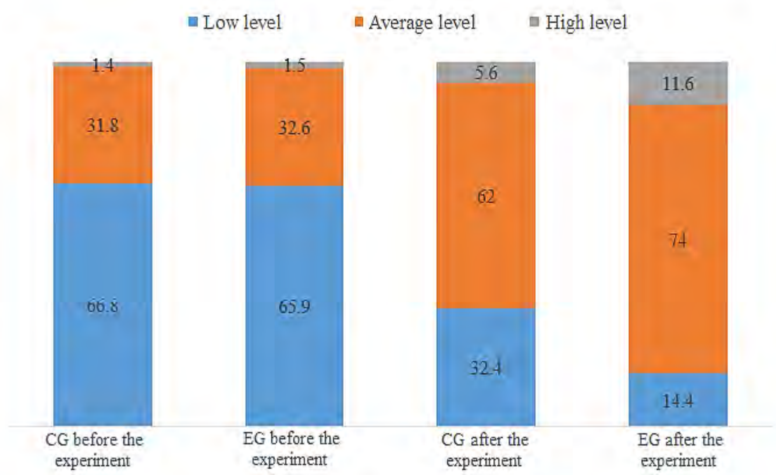

Figure 7. The results of a comparative analysis, ascertaining and control stages of the experiment according to the motivational criterion

The difference in the experimental groups according to the cognitive criterion at the high level of the criterion is 9.8%, and in the control groups – 4.6% (Figure 8), and on average 69.1% and 58.0%, respectively.

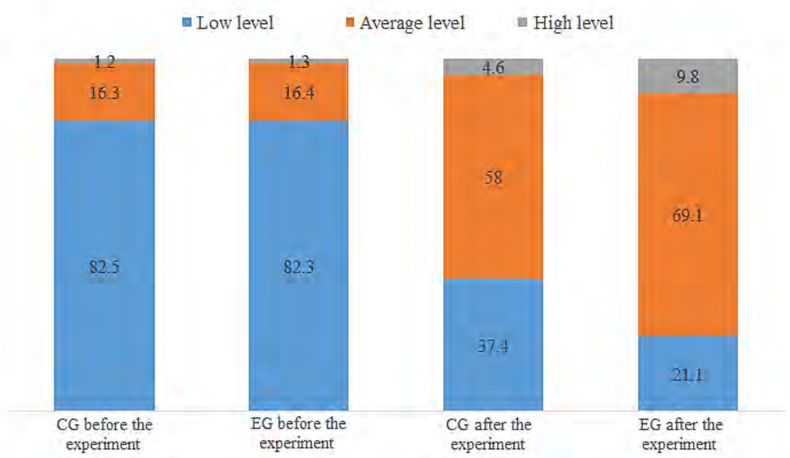

Figure 8. The results of a comparative analysis of the ascertaining and control stages of the experiment according to the cognitive criterion

Substituting the values of the corresponding variables into the formula for calculating the value of the Pearson criterion (Table 3), we obtain χ^2_{ex} for each criterion in the Table 7.

Table 7. The value of the test statistics χ^2_{ex} when comparing the distributions of future teachers from the experimental and control groups by the levels of the professional competence formedness after the experiment

Criteria of readiness	**Statistical values of the criterion χ^2**			
	Sample type	χ^2_{ex}	χ^2_{cr}	**Output**
Motivational criterion	EG CG	13.96	5.99	χ^2_{ex}>χ^2_{cr}
Cognitive criterion	EG CG	10.17	5.99	χ^2_{ex}>χ^2_{cr}
Communicative criterion	EG CG	10.03	5.99	χ^2_{ex}>χ^2_{cr}
Operational and pragmatic criterion	EG CG	19.2	5.99	χ^2_{ex}>χ^2_{cr}
Personality criterion	EG CG	7.94	5.99	χ^2_{ex}>χ^2_{cr}
Formedness	Arithmetic mean	11.2	5.99	χ^2_{ex}>χ^2_{cr}

The results of a comparative analysis of the ascertaining and control stages of the experiment (Table 8) showed a significant advantage of the developed methodological system of teaching by the chosen question of the methodology of teaching computer science (according to the averaged indicators), which is shown in Figure 9.

Table 8. Comparison of the results of the ascertaining and control stages of the experiment (%)

Criteria	**Group**	**Ascertaining stage**	**Formative experiment**	**Difference**	**Ascertaining stage**	**Formative experiment**	**Difference**	**Ascertaining stage**	**Formative experiment**	**Difference**
Motivational	EG	1.50	11.60	10.10	32.60	74.00	41.40	65.90	14.40	-51.50
	CG	1.40	5.60	4.20	31.80	62.00	30.20	66.80	32.40	-34.40
Cognitive	EG	1.30	9.80	8.50	16.40	69.10	52.70	82.30	21.10	-61.20
	CG	1.20	4.60	3.40	16.30	58.00	41.70	82.50	37.40	-45.10
Operational and pragmatic	EG	1.80	17.20	15.40	15.80	76.10	60.30	82.40	6.70	-75.70
	CG	1.90	9.80	7.90	15.20	64.20	49.00	82.90	26.00	-56.90
Communicative	EG	1.60	11.90	10.30	25.60	67.20	41.60	72.80	20.90	-51.90
	CG	1.40	7.60	6.20	24.80	54.00	29.20	73.80	38.40	-35.40
Personality	EG	1.70	12.40	10.70	14.90	67.50	52.60	83.40	20.10	-63.30
	CG	1.60	8.50	6.90	14.80	56.00	41.20	83.60	35.50	-48.10
Average	EG	1.58	12.80	11.22	21.06	73.10	52.04	77.36	14.10	-63.26
	CG	1.50	6.60	5.10	20.58	61.40	40.82	77.92	32.00	-45.92

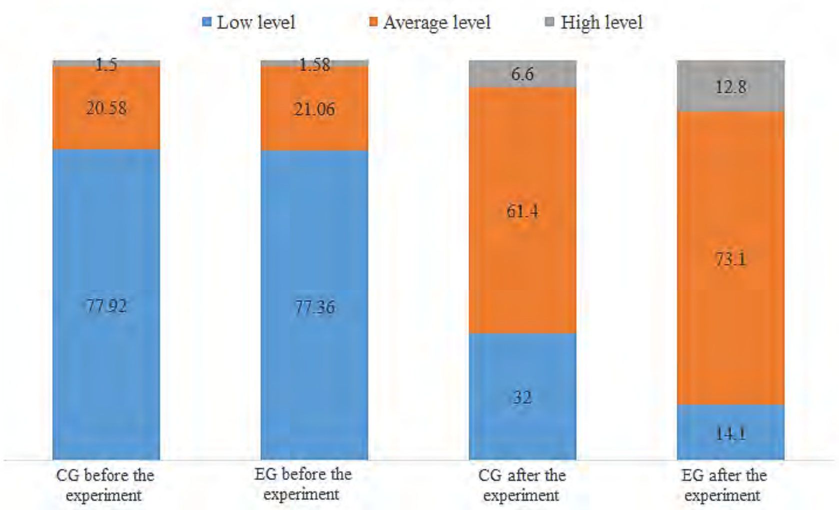

Figure 9. The results of a comparative analysis of the ascertaining stage of the experiment (according to the average indicator)

Comparison of the values of the criterion χ^2_{ex}=11.2, calculated from the data of the performed experiment and the critical χ^2_{cr}=5.99 for the significance level of 0.05 and the number of degrees of freedom 2, gives grounds for the conclusion that the differences in the distributions of the control and experimental groups by the levels of each criterion are statistically reliable and provide the effectiveness of the developed model for the professional competence formation, and, therefore, there is a confirmation of the alternative hypothesis that we put forward at the beginning of our experimental study. At a high level, the greatest changes were observed in the experimental group according to the operational and activity criterion: the difference was 15.40% (versus 7.90% in the control group). In our opinion, this is due to the fact that as a result of the expansion of the content of forms and methods of professional training within the framework of the developed course, students during quasi-professional activities could additionally develop the acquired practical skills. The smallest increase at a high level was recorded by the cognitive criterion: 8.5% in the experimental group and 3.4% in the control group. This is due to the practical orientation of the developed training content and the use of the competency-based approach as a leader in the process of organising experimental training. According to the average indicator at a high level, the difference in the experimental groups is 11.22% and in the control groups – 5.1%. Also, a more significant increase in the average indicator at the average level was recorded in the experimental groups, namely 52.04% (versus 40.82% in the control groups).

The results obtained confirm the reliability of the quantitative data obtained and show a positive dynamic of growth in the levels of formation of the studied indicators, which can be considered a confirmation of the effectiveness of the models and organisational and pedagogical conditions for the formation of professional competence of future computer science teachers in quasi-professional activities introduced into the methodological system of training future teachers. Based on the above, the goal of the study can be considered achieved.

5. Conclusions

Thus, the conducted experiment of students' achievements made it possible to record positive dynamics in both groups (control and experimental), however, the quantitative indicators of the criteria in the experimental group grew faster and with a greater difference against changes in the control group both for each of the criteria and for the average indicator. The analysis of the results of the formative stage of the pedagogical experiment confirmed the effectiveness of the developed forms, content and methods of forming the professional competence of future informatics teachers in quasi-professional activities.

It is beyond argument that modern school cannot exist without integration with information and communication technologies and building an information educational environment of the school, the integral parts of which are the school website, electronic document management, a sufficient number of computers connected to the Internet for organising the entire educational process, access to electronic libraries, archives, educational video collections, educational content management systems and much more. Of particular importance is the preparation of the future computer science teacher to work in the conditions of rapidly changing technologies, under the influence of which new trends in education are emerging. Today, a computer science teacher is a pioneer who independently learns and presents new opportunities to his colleagues. In accordance with the requirements of society for the level of training of a modern teacher, the training system in a higher education institution must also change.

Recommendations

Based on the results of the conducted investigation, the following recommendations for further research should be identified:

1. The use of information products in the learning process is worthy of being explored more.
2. Further study may include the possibilities of a structural understanding of teaching future computer science teachers when using a combination of information technologies with the need to use them in practice in a modern school.

Acknowledgements

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