The Development of Digital Competence of Future Teachers in the Process of Distance Learning

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Abstract—The article digital competence is considered, on the one hand, as a component of professional competence, and on the other – as a level of personal digital culture. The structure of the studied phenomenon defines the motivational component (motivation to use digital technologies in professional activities, focus on collective interaction, the desire to succeed through the possession of information technology); cognitive component (level of knowledge on the application of digital technologies in professional activities); activity component (skills and abilities to use digital technologies for the organization of educational activities and solving professional problems); personal component (ability to self-study, professional self-development in a digital society). The pedagogical conditions for the development of digital competence of future teachers are substantiated: creation and maintenance of the digital environment of a higher education institution; activation of independent educational and cognitive activity of students by means of information and communication technologies; actualization of innovative directions and technologies of development of digital competence of future teachers in distance learning. The research was conducted with the students of the first (bachelor's) level of higher pedagogical education. The results of diagnostic sections have been generalized, statistical analysis of which testifies to the effectiveness of the developed system of development of digital competence of future teachers.

Keywords—digital competence, information technologies, future teachers, professional training, distance learning

1 Introduction

Cotemporary digital space sets new goals on the professional training of future teachers, among which the priority is given to the mastery of information and communication and media educational technologies, means of presenting educational information, developing the ability to provide creative and exploratory learning, the ability to use multimedia technologies and digital tools in education. Digital technologies give the opportunity to operate with a large array of information, so an important skill of future teachers is the ability to organize information quickly, deter-

mine its value, application in professional activities, that is the question about the development of digital skills of the contemporary education specialist arises.

The significance of this problem is evidenced in educational legislation and regulations, particularly in the Law of Ukraine "On Higher Education" [1], the Concept of development of pedagogical education [2]. Present-day professional training of future teachers in higher education institutions also takes into account the requirements of international documents, educational standards and qualifications, including the European "The Digital Competence Framework for Citizens" [3], European Framework for the Digital Competence of Educators [4], Digital Europe Program for the period 2021–2027 [5], the Framework of Qualifications for the European Higher Education Area [6].

The issue of digital competence development of future teachers was especially acute during the pandemic outbreak of the coronavirus disease, when distance learning was implemented in all educational institutions of Ukraine. Therefore, the modern school needs a teacher who is able to respond quickly to globalizing world processes, to master the technologies of distance learning throughout life in a digital society. In this context, the question about anew view on professional training of future teachers arises, the content of which requires modification of the set of their competencies and focusing on one of the main – digital competence.

The purpose of the study is to test experimentally the effectiveness of pedagogical conditions for the development of digital competence of future teachers in terms of distance learning in higher pedagogical education.

2 Literature review

2.1 Content of digital competence of future teachers

The problem of developing digital competence of future teachers in the context of distance learning is the subject of the scientific community research around the world. In particular, Gudmundsdottir and Hatlevik consider the specific features of the formation of digital competence of future teachers, emphasize the insufficient use of digital technologies in the educational process of universities, the low level of digital competence of teachers [7].

The research of Iivari, Sharma, and Ventä-Olkkonen [8] focuses on the digital transformation of education, which is especially important during the COVID-19 pandemic. Digital competence is considered in the context of professional development of teachers, as the ability of each teacher to implement information and communication technologies in the educational activities of the educational institution [9], [10]. Krumsvik [11] expands the definition of digital competence of a teacher by introducing a holistic model that combines analytical levels and prerequisites for his individual potential.

The essence and structure of digital competence in the system of pedagogical education are considered in the studies of Lund, Furberg, Bakken, and Engelien [12].

The scientific research of Brevik, Gudmundsdottir, Lund, and Strømme [13] highlights general, didactic and professionally oriented digital competencies. The authors note that the development of digital competence of future teachers should take place through an integrated approach by introducing it into training seminars and pedagogical practice.

In our study, digital competence of future teachers is defined as an integrative personal education, characterized by the ability to understand and identify information needs (personal and professional), to process educational information through the use of digital technologies using the necessary information resources, software and hardware for effective educational and future professional activity.

2.2 The structure of digital competence of students

Romanovskyi, Grineva, Zhernovnykova, Shtefan, and Fazan in their article define the structure, criteria, indicators and levels of digital competence of future teachers of mathematics [14]. In their study Spante, Sofkova, Lundin, and Algers summarize the criteria for defining and assessing digital competence of teachers [15].

From the standpoint of our study, scientific interest is to determine the structure of digital competence of students of pedagogical specialties. As a result of summarizing the results of these studies, we have identified four components of this competence:

- motivational competence actualizes motivation to use digital technologies in professional activities, focus on collective interaction, the desire to succeed through the possession of information technology;
- cognitive component encourages the acquisition of knowledge on the application of digital technologies in educational and future professional activities;
- activity component implements the skills and abilities to use digital technologies for the organization of educational activities and solving educational and professional tasks;
- personal component provides the ability to self-study, professional self-development throughout life in a digital society.

2.3 Distance learning as a modern educational technology

Researchers Reysoglu Ilknur and Chebi Aycha [16] have developed a curriculum aimed at developing digital competencies in future teachers for their full use in professional careers, introducing creative approaches and materials that are adapted to the needs of students, their individual development during distance learning.

At present, the issue of development of digital competence of future teachers in the context of distance learning is relevant. Scientists Neroni, Meijs, Gijselaers, Kirschner, and de Groot [17]; Parusheva, Aleksandrova, and Hadzhikolev [18] substantiate the feasibility and possibility of using distance learning technologies in higher education institutions.

The study by Markova, Glazkova and Zaborova [19]; Liu, Lomovtseva and Korobeynikova [20] focuses on the active use of distance learning technologies in the edu-

cational process of student youth, which provide an opportunity to overcome the problems of traditional learning (attachment to the territory, time limits, lack of independent student activity); meeting the individual educational needs of the student and the realization of his creative potential.

In our opinion, distance learning is an individualized form of organization of professional training, which takes place through the indirect interaction of distant participants in the educational process in a specialized environment that operates on the basis of modern psychological, pedagogical and information and communication technologies.

Practical aspects of distance learning were discussed in the works of Kitsantas, and Chow [21]; Beyth-Marom, Chajut, Roccas, and Sagiv [22]; Offir, Barth, Lev, and Shteinbok [23]; Hillesheim [24]. Researchers Ferrer, and Kirschning [25] propose a method of developing distance learning tasks adapted to the student's learning style.

The development of digital competence of future teachers takes place in the process of professional training. Therefore, it is necessary to create pedagogical conditions that provide this process in higher education institutions. We are guided by the statement that the pedagogical condition is an essential component of the educational process and combines the content, methods, organizational forms of teaching and is focused on the development of digital competence of future teachers.

3 Methodology

3.1 Respondents and experts

The study was conducted during 2019–2021 with the students of Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Bohdan Khmelnytsky Cherkasy National University, Pavlo Tychyna Uman State Pedagogical University. 232 people were involved in various forms of experimental work, including 225 students of the first (bachelor's) level of specialty 014 Secondary education, 7 experts – the teachers of pedagogical universities, teachers of secondary schools, information technology specialists.

Second- and fourth-year students were grouped into a control group (CG) of 116 people and an experimental group (EG) of 109 people.

3.2 Diagnostic tools for the study of digital competence

To determine the level of digital competence of future teachers the following were used: orientation questionnaire by Bass [26]; test tasks "Basic concepts of digital teacher culture", method "Digital activity of a modern teacher" [27]; methods of diagnostics of reflexivity by Karpov, and Ponomareva [28]; methods of studying the level of self-knowledge of a teacher by Rogov [29]; method of studying the level of desire for self-development by Berezhnova [30]. The components of the diagnostic portfolio mentioned above were selected to obtain data on the indicators of motivational, cognitive, activity and personal components of digital competence of future

teachers. The value of digital competence is calculated as a weighted average of the number of relevant components.

The obtained results are interpreted on the accepted scale: low level: 0–0.74; average level: 0.75–1.49; sufficient level: 1.50–2.24; high level: 2.25–3.0.

3.3 Scalogram analysis of pedagogical conditions

To study the pedagogical conditions for the development of digital competence of future teachers in terms of distance learning by the method of Guttman [31], we used the following algorithm:

Selection of judgments – pedagogical conditions. We highlighted the most common and effective conditions for the development of digital competence of future teachers in distance learning, in particular:

a) Development of positive motivation of future teachers to use digital technologies in educational and future professional activities.
b) Creating and maintaining the digital environment for higher education.
c) Actualization of modern directions and technologies of development of digital competence of future teachers in distance learning
d) Directing the content of disciplines of professional and practical training on the development of components of digital competence.
e) Enriching the content of professional training of future teachers with the issues of digitalization of educational activities.
f) Activation of independent educational and cognitive activity of students by means of information and communication technologies.

Expert ranking of pedagogical conditions was carried out by a group of 7 specialists. An important characteristic of the experts was their working experience in the field for more than five years, and all scientific and pedagogical workers had a scientific degree. This ensured high representativeness of the sample.

Expert assessment. the experts are offered cards on which the selected pedagogical conditions are written. The respondent's score is equal to the sum of positive reactions (number of "+" signs) to pedagogical conditions. Determining the consistency of experts' opinions is done by calculating a numerical value that characterizes the degree of closeness of individual opinions. Analysis of the value of the degree of coordination contributes to the grouping of opinions of experts and obtaining the correct judgment about the choice of a particular pedagogical condition.

Data Processing. The data of the expert surveys are arranged from pedagogical conditions that express a positive attitude to the object of evaluation to those that express an unfavorable attitude.

Checking the scale for reproducibility. The reproducibility ratio determines the possibility of separating the pedagogical conditions according to the answers of experts. The possible number of deviations from the ideal scale is determined by the formula:

$$V = 1 - \frac{n}{K \cdot N}, \tag{1}$$

where V is the reproducibility factor; n is the number of erroneous answers; K – the number of points on the scale, which must be answered; N – number of experts. In our case:

$$V = 1 - \frac{6}{6 \cdot 7} = 0{,}86\,. \tag{2}$$

Judgments are considered suitable for scaling if the reproducibility factor is V ≥ 0.85. It characterizes the degree of approximation to the ideal scalogram, in which the reproducibility ratio is 1.00.

Mathematical processing of the received data. The rank of each condition is determined by the total number of points. Then we calculate the arithmetic mean of this pedagogical condition, compare with the ranks of other conditions. The average rank of the category shows the general attitude of experts on the object or phenomenon under study. Thus, it is possible to summarize the agreed-identical answers of experts in the context of each of the outlined pedagogical conditions, as well as to present them in the form of a matrix – from the most significant to the least significant (Table 1).

Table 1. Ranking matrix according to the level of significance of pedagogical conditions

Rank	Pedagogical conditions					
	B	***C***	***F***	***A***	***E***	***D***
1	7	1	0	1	1	1
2	0	6	1	2	1	1
3	0	0	6	0	1	1
4	0	1	0	2	1	1
5	0	0	0	1	2	2
6	0	0	0	1	1	1

According to the data given in Table 1, the first three ranks were occupied by the following conditions:

1. creation and maintenance of the digital environment for higher education institutions;
2. activation of independent educational and cognitive activity of students by means of information and communication technologies;
3. actualization of current trends and technologies of development of digital competence of future teachers in distance learning.

3.4 Data analysis

Mathematical and statistical methods (averages, pairwise comparisons) were used to process and present the results of experimental research, analysis, determination of indicators of digital competence development of future teachers. Sample representativeness calculations were performed using the Statistica software environment.

4 Results and discussion

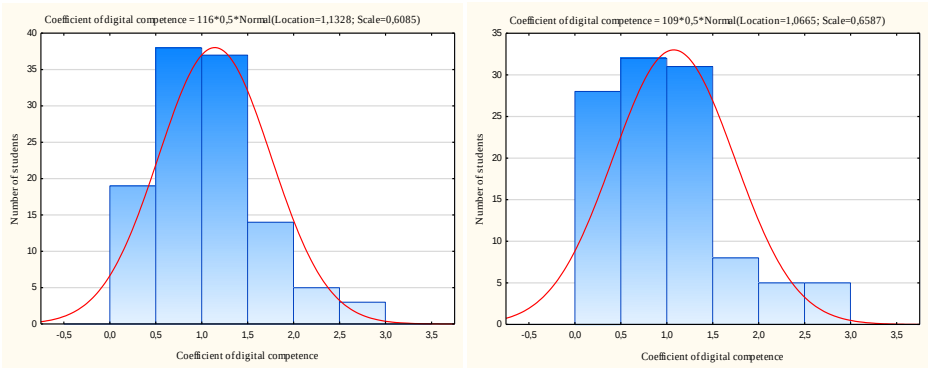
The results of diagnostics of the levels of digital competence development of students in CG and EG at the initial stage of the study are presented in Table 2, Figure 1.

Table 2. Levels of digital competence development of future teachers (statement section, in %)

Components	Control group				Experimental group			
	Levels							
	Low	***Average***	***Sufficient***	***High***	***Low***	***Average***	***Sufficient***	***High***
Motivational	24.1	45.7	20.7	9.5	24.8	45.9	19.3	10.1
Cognitive	38.8	44.0	10.3	6.9	38.5	41.3	13.8	6.4
Activity	41.4	37.1	18.1	3.4	42.2	37.6	15.6	4.6
Personal	37.1	45.7	9.5	7.8	37.6	44.0	10.1	8.3
Digital competence	35.3	43.1	14.7	6.9	35.8	42.2	14.7	7.3

According to the obtained data, it can be stated that 35.3% of CG respondents and 35.8% of EG were identified at a low level of digital competence development; the average level was recorded in 43.1% of CG students and 42.2% of EG; a sufficient level is observed in 14.7% of students in each group; only 6.9% of CG students and 7.3% of EG are at a high level.

Figure 1 in the form of histograms shows the distribution of future teachers of CG and EG according to the general results of the success of tasks to determine the levels of digital competence development.



Control group Experimental group

Fig. 1. Histogram and curve of normal distribution of students by levels of development of digital competence at the ascertaining stage of research

The histogram data show that 41 CG students and 39 future EG teachers fell into the range of 0–0.74. In the range of values from 0.75 to 1.49 were 50 students of CG and 46 students of EG; up to the range of 1.5–2.24 – 17 CG students and 16 EG students; up to the range of 2.25–5 – 8 students from each group.

The outlined indicators confirm the homogeneity of the sample of future teachers of the control and experimental groups. The histogram shows that the results of diagnosing students in CG and EG are homogeneous and subject to the law of normal distribution. The discrepancy between the results of diagnosing the development of digital competence of students in the control and experimental groups is not statistically significant, which allows us to consider them as a whole.

The data obtained during the ascertaining stage of the experiment became the basis for concretization of measures for the development of digital competence of future teachers. Further experimental research involved the implementation of pedagogical conditions in the experimental groups, in the control groups no special work was carried out.

The digital environment of higher education was created and maintained based on integration of information data on digital media, information communication technologies, which unites virtual libraries of full-text electronic resources, information materials, structured e-learning courses, environments for teamwork and educational process management. The digital environment for distance learning has allowed us to:

- organize various forms of activity of students on independent study of educational material;
- apply all current information and telecommunication technologies in the process of performing various types of educational activities: interactive dialogue, modeling of objects, phenomena, processes, functioning of virtual laboratories, etc.;
- use multimedia technologies, hypertext and hypermedia systems in the educational process;
- diagnose the academic achievements of students, as well as the level of their preparation for a particular lesson;
- manage training, automate processes of control of results of educational activity, training, testing, give tasks depending on the intellectual level of each student, level of his/her knowledge, abilities, skills, features of motivational sphere;
- create conditions for the organization of independent educational activity of future teachers, for self-learning, self-development, self-improvement, self-education, and self-realization;
- develop skills of teamwork in digital environment, provide management of information flows.

When teaching professional disciplines, we had a pedagogical influence on the development of components of digital competence of future teachers. In particular, students were introduced to the specifics of the future profession in modern conditions, which combines the implementation of educational activities with the use of information technology and changing approaches to interpersonal interaction in the process of distance learning.

To implement research tasks, we have updated the content of the disciplines of the curriculum for the successful formation of a system of knowledge, skills and abilities to use information and digital technologies in professional activities; the training practice “Distance Learning Tools” has been optimized and the content of its program has been improved.

Professional training of students of the experimental group in the process of distance learning included the following forms of the educational process organization: problem lectures, lectures-visualizations, lectures-presentations, lectures-dialogues, seminars, independent work. Technological tools are provided by using the following methods: pedagogical situations, portfolio, project method, logical-semantic models, debates, microteaching, synectics, discussions, heuristic conversations, mind maps, emotional stimulation of learning, etc.

In practical classes, pedagogical practice provides for the use of information and communication technologies. We used technological tools: virtual class, master class, project method, portfolio, mind map, microteaching, mutual reflection, mutual learning, modeling, etc.

Activation of independent educational and cognitive activity of students by means of information and communication technologies directed students to independence in acquiring knowledge, provided development of difficult abilities and skills to see the purpose and the maintenance of work, to organize self-education, ability to take a new approach to solving individual tasks aimed at cognitive and mental activity, the ability to be creative and able to carry out a research. The updating of contemporary directions and technologies of digital competence development of future teachers is ensured by the introduction of digital technologies in the educational process of training students to meet the informational, intellectual, cultural and communication needs of the individual: information modeling, case methods, smart technologies, project method, data digitization.

Therefore, both electronic educational resources and software environment for academic success are available for the needs of students. Based on cloud technologies, professional training allows the most effective implementation of services to provide students with educational resources at the current level and the development of their digital competence.

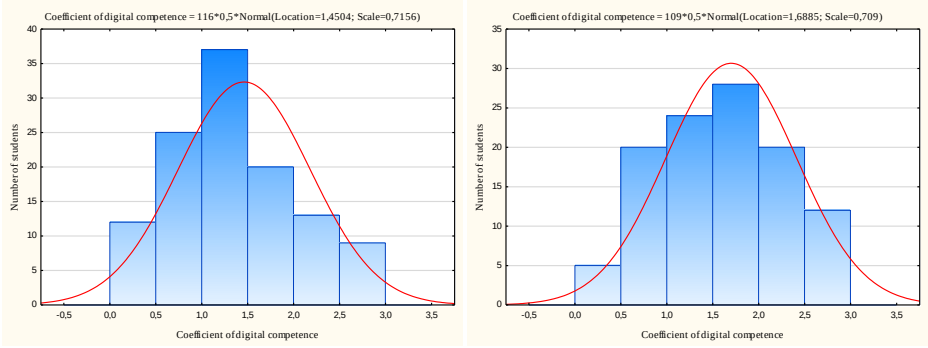
At the end of the experimental work, we performed control sections. The comparative characteristics of the results of the distribution of students of the control and experimental groups (Table 3, Figure 2), according to the levels of development of digital competence compared to the statement stage showed significant positive changes in the experimental group in contrast to the control, where there were insignificant positive changes.

Table 3. Levels of development of digital competence of future teachers (final section in %)

Components	**Control group**				**Experimental group**			
	Levels							
	Low	***Average***	***Sufficient***	***High***	***Low***	***Average***	***Sufficient***	***High***
Motivational	17.2	40.5	27.6	14.7	11.9	18.3	45.0	24.8
Cognitive	31.9	33.6	21.6	12.9	15.6	22.0	43.1	19.3
Activity	27.6	31.0	31.9	9.5	17.4	19.3	40.4	22.9
Personal	26.7	36.2	25.9	11.2	13.8	21.1	44.0	21.1
Digital competence	25.9	35.3	26.7	12.1	14.7	20.2	43.1	22.0

The analysis of the final data to determine the levels of development of digital competence of future teachers allows us to draw the following conclusions. One third of students remained at a low level in CG –25.9%, while in EG – only 14.7%. The average level of digital competence changed in both groups: in CG it is 35.3%, while in EG – almost twice less – 20.2%. At a sufficient level of development of digital competence was 26.7% of CG students and twice as many EG students –43.1%. The effectiveness of the proposed pedagogical conditions is demonstrated by the results of the high level of development of digital competence of future teachers, which in CG and EG differs significantly: 12.1% and 22.0%, respectively.

The distribution of CG and EG students based on the results of diagnosing the levels of digital competence development of future teachers is reflected in Figure 2.



Control group Experimental group

Fig. 2. Histogram with a curve of normal distribution of students on the generalized results of diagnostics of digital competence (at the end of the experiment)

Thus, a comparative analysis of the results shows that the number of future teachers with a high level of digital competence development increased after experimental work in both CG and EG, but in the experimental group these changes were more significant. In general, these histograms show the results of diagnosing students by levels of development of digital competence of future teachers in CG and EG are homogeneous and subject to the law of normal distribution. The dynamics of all levels of digital competence development of students in CG and EG after the formative stage of the experiment is presented in Figure 3.

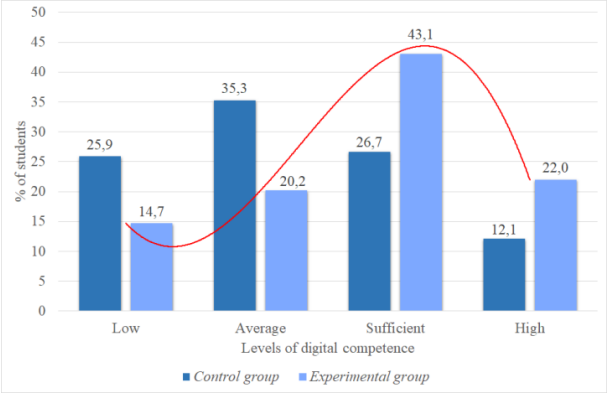


Fig. 3. Comparative characteristics of the levels of digital competence development of future teachers at the end of the experiment

The results of diagnostic sections show the effectiveness of the implementation of pedagogical conditions for digital competence of future teachers. As a result of the pedagogical experiment, high-level digital competence in experimental groups increased by 14.7%, at a sufficient level – by 28.4%, in control groups – by 5.2% and 12.0%, respectively, which is explained by the effectiveness of the developed system.

5 Conclusion

According to the results of the analysis of normative documents, scientific and methodical works it is established that the development of digital competence of future teachers takes place in the process of professional training. According to our interpretation, the concept of "digital competence of future teachers" is an integral quality of a personality, characterized by the ability to understand and identify information needs, process educational information using digital technologies with the necessary information resources, software and hardware for effective educational and future professional activity.

Digital competence of future teachers as a personal education is a holistic set of such interconnected structural components: motivational (deepening awareness of the need to use digital technologies in professional activities, focus on collective interaction, the desire to succeed through information technology), cognitive (formation of personally acquired knowledge of contemporary digital learning technologies, methods of professional activity on the basis of information and communication technologies), activity (a set of skills and abilities related to the use of digital technologies for the organization of educational activities and solving professional problems); personal (ability to self-study, professional self-development in a digital society).

It is established that the development of digital competence of future teachers is provided by the following pedagogical conditions: creation and maintenance of digital environment of higher education institution; activation of independent educational and cognitive activity of students by means of information and communication tech-

nologies; actualization of modern trends and technologies of digital competence development of future teachers in distance learning. The positive influence of the proposed conditions on the development of all components of digital competence of future teachers has been experimentally shown.

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