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The Use of Digital Technologies in Professional Training of Primary School Teachers

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Abstract

The growing significance of digital technologies in society creates a need to train teachers who can use these technologies in the educational process and prepare students for life in the digital world. The aim of this study was to analyse the impact of digital technologies used in professional training of primary school teachers on increasing their professional competence level. The adapted versions of Ferrell & Daniel's test for Measuring Teacher Career Motivations, the Orshanski's orientation of future teachers towards humanistic and professional value were used to diagnose the state of development of professional competence. The level of the development of the subject-subjective model of pedagogical communication (modified test based on Sternberg & Williams, Alexander & Winne) and the level of projective skills in primary school teachers were also diagnosed. The students' performance was assessed based on the results of the examinations. Chi-squared test ($\chi 2$) was used for statistical confirmation of the conducted research. Positive dynamics were found in both groups after the formative stage of the experiment. However, the experimental group was noted for greater quantitative and qualitative improvement for the selected criteria. The largest changes were observed for the operational criterion with a difference of 15.40% (against 7.90% in the control group). The cognitive criterion showed the smallest increase: 8.5% in the experimental group compared to 3.4% in the control group. The high general mean showed a difference of 11.22% for the experimental group and 5.1% for the control group. It is also important to note a greater increase in the average indicator at the general level in the experimental group of 52.04% compared to 40.82% in the control group. The differences in the distributions of the control and experimental groups according to the levels of each criterion are statistically reliable and testify to the effectiveness of using digital technologies for the development of professional competence of future primary school teachers. The areas for further research include the analysis of the impact of digital technologies on the development of information literacy skills and critical thinking.

Keywords:

Education, Digital Technologies, Pedagogical Training, Primary Education, Innovations In Education, Computer Training

Introduction

The modern world is experiencing rapid development of digital technologies. This transformation affects all areas of our lives, including education. It becomes especially important in professional training of primary school teachers. Now, children are growing up in a world where digital technologies have become an integral part of their daily lives, so teachers must be ready to use these technologies to improve learning and support children's development.

The use of digital tools and teaching methods is important to teach primary school teachers to be flexible and adaptable to changes. The ability to use digital tools will help them better adapt to new technologies and pedagogical approaches. When it comes to the professional training of future primary school teachers, it should be understood that at least 2-3 years will pass from the time of education of current students to the beginning of their pedagogical activities. According to the Pew Research Center, those born after 1997 and before 2012 belong to the so-called Generation Z (Dimock, 2019). This is the average statistical age of today's students of pedagogical specialties (representatives of generation Z are 12-27 years old as of 2024). The defining characteristics of representatives of this generation are defined as authentic digital natives who are a hyper cognitive generation, students of Generation Z (other names - iGeneration, Gen Tech, Online Generation, Facebook Generation, Switchers, "always clicking") are always connected to the network and fast in all types of activities they perform, including decision-making and implementation (Dolot, 2018). This means that an educational environment filled with digital technologies is the most and only optimal environment for the personal and professional development of students of higher education. However, it is worth taking into account, first of all, the fact that today's students will already teach those students of the category of primary school students who will belong to the Generation Alpha or the Google Kids generation born between 2010 (2012) and 2025 and even beyond (Hernandez-de-Menendez et al., 2020; Cickovska, 2020). It is predicted that the next generations will become even more attached to the world of digital technologies. Since the technological process is irreversible, this means that training future primary school teachers using digital technologies is not only the optimal way to build an educational paradigm for them (Generation Z), but the only way to make them competent in relevant teaching practices for use in independent pedagogical activities (for teaching young schoolchildren of the Generation Alpha and beyond). That is why the topic of the current article is acutely relevant and timely.

Lewin et al. (2019) note that digital technologies can improve the quality of learning and student assessment. Although digital technologies are well integrated into higher education environments, their impact on student achievement of higher education goals has not been empirically proven (Lacka et al., 2021).

Therefore, despite the large number of studies on this problem, there are not enough practical studies on the use of digital technologies in the professional training of primary school teachers.

The aim of this study is to analyse the impact of the use of digital technologies in the process of professional training of primary school teachers on increasing their level of professional competence.

The main objectives determined by the relevance of the issue under research are the following:

- determine the initial level of professional competence of future primary school teachers;

– research and analysis of the results achieved through the implementation of digital technologies in the educational process of primary school teachers;

- analysis of opportunities and limitations of using digital technologies in the process of training primary school teachers.

Literature Review

Modern universities should revise their approach to education, moving away from the idea of training ready-to-work graduates. Instead, they should focus on providing students with knowledge and experience at the early stages of their studies, actively engaging them in technological innovation (Nguyen, 2018; Prensky, 2008). Researchers single out a number of key competencies, the formation of which is necessary for high-quality professional training of future teachers, in particular primary school teachers (Albarra Shidiq et al., 2022). These are such teachers' professional competencies as motivational (Chagovets et al., 2020), cognitive (Bardach & Klassen, 2020), communicative (Atavullayeva, 2023), operational activity criterion (Sharofutdinova, 2021) and personality (Vorkapić & Peloza, 2017; Kokkinos, 2007) of primary teachers. Nevertheless, one of the most relevant is the identification and characterization of digital competencies (Fernández-Batanero et al., 2022). However, the last one is already included into the recently adopted and implemented Professional Standard of Primary School Teachers (Ministry of Education and Science of Ukraine, 2020) as a separate competency. It is verbalized as information and digital competency. Nevertheless, it has an umbrella nature and penetrates as a supportive one into other listed competencies: linguistic and communicative, subject-methodical, psychological, emotional and ethical,

pedagogical partnership, inclusive, health-preserving, design, prognostic, organizational, evaluative and analytical, innovative, reflexive, lifelong learning ability. Research emphasizes the importance of digital competence as one of the challenges facing teachers today. There are also many typical shortcomings, which are manifested in insufficient quality digital competence in initial teacher training (Björk & Hatlevik, 2018).

When we talk about the digitization of the economy and society, we define it as an evolution that takes place due to the introduction and spread of digital technologies affecting all spheres of life and economy. In turn, digitization of education means the use of digital means to create, process, exchange and transfer information in the educational process (Shaxnoza, 2022). Digitalization is currently defined as "a series of profound and coordinated changes in culture, workforce, technology and operating models" (Brooks & McCormack, 2020, p. 3) that lead to cultural, organizational, and operational changes through the integration of digital technologies (Iosad, 2020).

The education in the modern world is aimed at technological learning and increasing the usability of new learning tools (Dudnyk, 2018; Marttinen et al., 2019). It is important not only to master new technologies, but also to adapt them to specific needs and tasks in a timely manner. Education becomes a process where a skill that is relevant today may lose its relevance tomorrow. This approach can be referred to as Education 4.0, where the emphasis is on combining learning with modern technologies and continuous improvement of skills taking into account changes in society and the labour market (Khan & Qureshi, 2020).

Technological improvements in education make life easier for students. Instead of using pen and paper, students use a variety of software and tools to create presentations and projects (Haleem et al., 2022).

Digital technology goes beyond innovative and less traditional teaching and learning methods through educational collaboration (Qureshi et al., 2021). It is an indisputable fact that computer technologies improve new ways of learning and teaching. The goal of integrating digital technologies into the educational process is to improve the quality of education (Singh, 2021). ICT helps the teacher to present the material in an understandable form for students at any level of education (Ratheeswari, 2018; Stringer et al., 2021).

The advantages of digital technologies in education include:

– digital technologies provide instant access to the necessary information and train important skills in working with information sources;

- contribute to the formation of information culture;

- help the teacher to automate or simplify the performance of a number of tedious duties;

- ensure greater accessibility of education through the use of distance learning;

- enable using didactic tools in various forms of education (Shahid et al., 2019; Aroyev & Juraev, 2023; Cevikbas et al., 2023).

The list of disadvantages of online education can include such points as:

– unequal access: not all students and educational institutions have the same level of access to digital technologies;

– many teachers and students may not have sufficient skills in using digital tools;

– constant access to digital devices can lead to distraction from learning and contribute to the development of addiction to social networks and entertainment;

– in some cases, the use of digital technologies can contribute to social isolation, as students can interact less personally and communicate less with fellow students;

– the problem of overload may arise because of an easy access to a large amount of information, when students cannot effectively process and analyse large data flows (Moraes et. al., 2023).

Figure 1

The Main Types of Digital Technologies

Methods and Materials

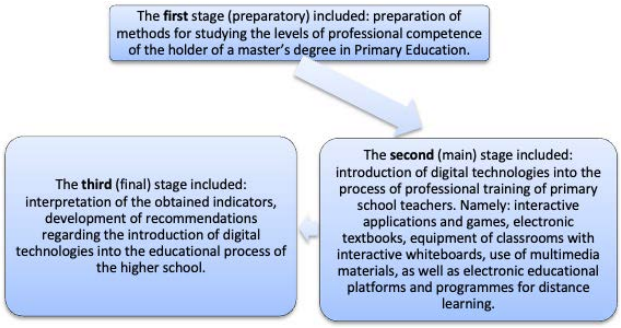
Research Design

The method of the study is experimental. The theoretical basis for the current experimental study was the conclusions from the conducted literature review and the results of analytical and theoretical studies. In particular, those regarding the theoretical basis and practical prerequisites for the formation of digital competence of future primary school teachers, namely the works of Aidarbekova et al. (2021), Robles Moral and Fernandez Diaz (2021), Porln and Sanchez (2016), and Pongsakdi et al. (2021). In particular, in the work, we used the idea of influencing, thanks to the use of digital technologies in the process of professional training of primary education specialists, to increase their level of professional competence.

The study was organized in three stages from September 2021 to May 2023.

Figure 2

Stages of the Research



Sample

The experimental base of the study was randomly selected higher education institutions: Mukachevo State University, Ferenc Rakoczi II Transcarpathian Hungarian College of Higher Education, Yuriy Fedkovych Chernivtsi National University and Kamianets-Podilskyi Ivan Ohiienko National University.

As of the beginning of the 2022/2023 academic year, 16,804 students studied in Ukraine at the second (Master's) level majoring at 013: Primary Education on a full-time basis, who made up the general population of the sample (State Statistics Service of Ukraine, 2022; Ministry of Economic Development, Trade and Agriculture of Ukraine, 2020). Master's students were chosen for the experimental study because they already have an initial level of professional competence. After calculating the size of the required (representative) sample using an online calculator (with parameters: confidence probability - 85%, error - 10%), the size of the valid sample was 264 people. This number was the starting point for forming the experimental group (EG) (n = 134) and the control group (CG) (n = 130). The experimental data of each team were tested for normality of distribution using the one-sample Kolmogorov-Smirnov test λ.

Data Collection and Analysis

The criteria and indicators of the level of professional competence of Master's students were distinguished in order to diagnose it. The basis was the Professional Standard of Primary School Teachers (Ministry of Education and Science of Ukraine, 2020) valid in Ukraine. Each criterion of professional competence was diagnosed by appropriate methods (Table 1).

To assess the general level of readiness of future primary school teachers for each evaluation method, an indicator was determined at the following levels: objective, objective-subjective, subjective-functional, subjective-activity, transformative, which were assigned points 1, 2, 3, 4, 5 in the order of their presentation. The general level was defined as the arithmetic mean. The absolute error of this experiment did not exceed 0.5 points.

The SPSS 17.0 package was used for statistical data processing. The chi-squared test (χ^2) was used for statistical confirmation of the conducted research, the value of which is calculated according to the formula 1, using classical designation:

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

where n_1 and n_2 are the 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 the state of the studied property (in our case, to the groups of students with high, medium, and low levels of competencies), Q_{21}, Q_{22}, Q_{23} — the number of objects of the second sample that fell into the category of the state of the studied property (for groups of students with high, medium, and low levels of competencies).

Ethical criteria

The respondents' participation in the study was voluntary, the principles of protecting the rights of research participants, ensuring their safety and data confidentiality were observed in the process of data collection. The research was based on the principles of impartiality and objectivity.

Results

Ferrell & Daniel's test for Measuring Teacher Career Motivations was used in order to diagnose the motivational criterion (Ferrell & Daniel, 1993). The cognitive criterion was evaluated based on the results

Table 1

Diagnostic Tools of Future Teachers' Professional Competence

Criterion	Indicators	Methods
Motivational criterion	nature of professional motives; manifestation of value attitude towards oneself as a future primary school teacher; manifestation of a value attitude to the processes, phenomena, and subjects of primary school; willingness to work with children, to contribute to their development and education. the ability to motivate students to study and achieve success.	K. Zamfir's Motivation for Professional and Ferrell & Daniel's Test for Measuring Teacher Career Motivations for detecting professional and pedagogical activity (Ferrell & Daniel, 1993).
Cognitive criterion	the level of specific professional, didactic and methodical, psychological and pedagogical, differential and psychological, as well as socio-psychological knowledge; flexibility, reflecting the ability to interpret knowledge, apply it in both standard and problem situations; practicality, which implies the possibility of practical implementation of the acquired knowledge in order to fulfil professional tasks.	Evaluation of students' performance based on the results of the examinations
Communicative criterion	the ability to effectively interact with students of different age groups; the ability to clearly and effectively express instructions and explanations; the ability to listen and understand the students' questions and needs; the ability to use different methods of communication (oral language, written language, non-verbal communication); the ability to cooperate with students' parents and families, including open and effective exchange of information; the ability to resolve conflicts between students or students and colleagues; the ability to give constructive feedback to students to improve their educational activities.	Diagnostics of the level of subject-subjective model of pedagogical communication (according to Sternberg and Williams (2010); Alexander and Winne (2012))
Operational and activity criterion	development of projective and constructive, analytical, organizational and communicative skills; striving for self-realization as a primary school teacher; subjective professional position; pedagogical activity; subjective experience; empathy.	Diagnostics of the level of projective skills in primary school teachers Boyko (2013a)
Personality criterion	the ability for self-awareness and self-improvement; the ability to recognize and analyse one's own strengths and weaknesses in the role of a teacher; the interest in own professional development and training; emotional stability and empathy; compliance with ethical norms and standards in teaching and relations with students, parents, and colleagues; flexibility and adaptability.	the Teachers' Humanistic Value Orientations (test by Orshanski's (2018) orientation of future teachers towards humanistic and professional value)

of the students' performance at the examinations. The communicative criterion was evaluated using the diagnostics of the level of subject-subjective model of pedagogical communication (modified test based on Sternberg & Williams, Alexander & Winne). The operational and activity criterion was determined by diagnosing the level of projective skills of a primary school teacher (Boyko, 2013b). The personality criterion was determined by using the Teachers' Humanistic Value Orientations – Orshanski's (2018) orientation of future teachers towards humanistic and professional value.

The experimental and control groups of students with approximately the same distribution according to the levels of certain criteria were formed to conduct the summative stage of the pedagogical experiment (Table 2).

Table 2

The Level of Professional Competence of Future Primary School Teachers (Results of the Summative Stage of the Experiment (as a Percentage))

Criteria	High level		Medium 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 activity	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
Mean	1.5	1.58	20.58	21.06	77.92	77.36

So, the results of the surveys and the diagnostic test of the level of professional competence of future primary school teachers confirmed the relevance of the research and made it possible to draw the following conclusions: the vast majority of students have a low level of the studied phenomenon both on average and in terms of individual criteria, which significantly affects the quality of further professional activity.

Before starting the experimental research at the summative stage, we put forward a null (H_0) and an alternative (H_1) hypothesis.

H_0: The level of professional competence of future primary school teachers has not changed significantly.

H_1: The level of professional competence of future primary school teachers has undergone significant qualitative changes.

To calculate the value of the X^2_{ex} statistics, we enter the designation corresponding to the one used in the formula for calculating the value of the Pearson's chi-squared test and make the necessary calculations. We compiled auxiliary Table 3. By substituting the values of the relevant variables into the formula for calculating the value of the Pearson's chi-squared test, we will get X^2_{ex} for each criterion of the professional competence of future primary school teachers.

Table 3

An Auxiliary Table for Calculating the Value of X2ex when Comparing the Distributions of Future Teachers of the Experimental and Control Groups According to the Levels of Professional Competence at the Beginning of the Experiment

Sample	The number of teachers	The number of students with high level	The number of students with a medium level	The number of students 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 activity 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

Table 4 shows the values of the criteria calculated for the data of our experiment according to the motivational, cognitive, communicative, operational and activity, and personality criteria of the professional competence of future primary school teachers according to the table values.

So, the obtained results provide grounds to state that the selected groups of future primary school teachers of the experimental and control groups are equivalent according to the specified criteria.

According to certain characteristics of the levels of indicators of each criterion of the professional competence, the future teacher could fall into one of three categories: a group with a low level, a group with a medium level, a group with a high level of the indicators and criteria of the professional competence.

The analysis of the results showed a significant increase in the quantitative indicators of the criteria in the experimental group, while the changes were insignificant in the control group. Table 5 shows the obtained results.

The general sample population of students was 264 people. Despite the positive trend, which is manifested in the increase (decrease) in the indicators of the levels of students' performance in the experimental and control groups, the qualitative results are significantly higher.

Table 4

The Value of the Criterion Statistics when Comparing the Distributions of Future Primary School Teachers of the Experimental and Control Groups According to the Levels of Professional Competence at the Beginning of the Experiment

Readiness criteria		X^2_{ex} statistics		
	Sample	X^2_{ex}	X^2_{ex}	Result
Motivational criterion	EG CG	0.05	5.99	$\chi^2_{excr\rightarrow} < \chi^2$
Cognitive criterion	EG CG	0.004	5.99	$\chi^2_{excr\rightarrow} < \chi^2$
Communicative criterion	EG CG	0.02	5.99	$\chi^2_{excr\rightarrow} < \chi^2$
Operational and activity criterion	EG CG	0.012	5.99	$\chi^2_{excr\rightarrow} < \chi^2$
Personality criterion	EG CG	0.05	5.99	$\chi^2_{excr\rightarrow} < \chi^2$

Table 5

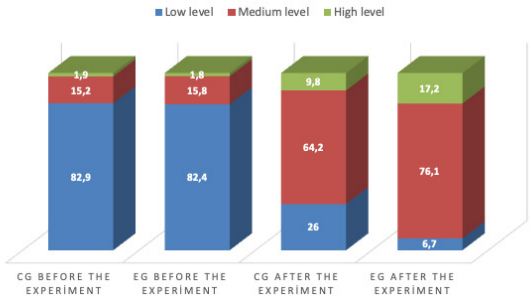
Results of the Control Stage of the Experiment (as a Percentage)

Criteria	High level		Medium 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 activity	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

At the high level, the greatest increase was found for the operational and activity criterion (9.8% in the control groups and 17.2% in the experimental groups, and 64.2% and 76.1%, respectively, at the medium level) (Figure 3).

Figure 3

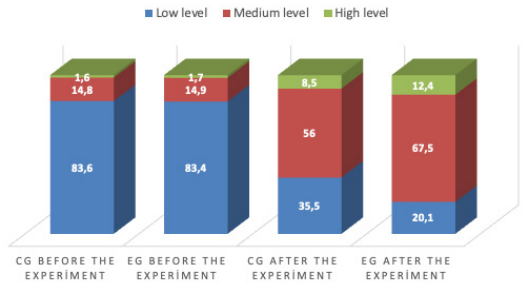
Results of the Comparative Analysis of the Summative and Control Stages of the Experiment for the Operational and Activity



According to the personality criterion at a high level, the difference in the experimental groups is 12.4%, and in the control groups — 8.5%, and on average 56% and 67.5%, respectively (Figure 4).

Figure 4

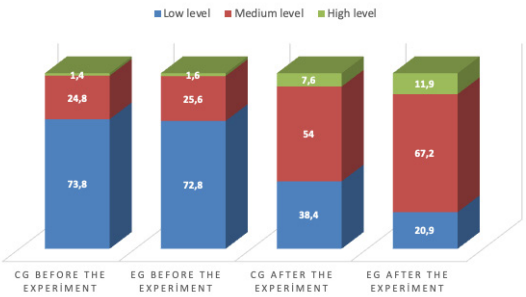
Results of the Comparative Analysis of the Summative and Control Stages of the Experiment for the Personality Criterion



For the communicative criterion at a high level, the difference in the experimental groups is 11.9% compared to 7.6% in the control group (Figure 5), on average 67.2% and 54.0%, respectively.

Figure 5

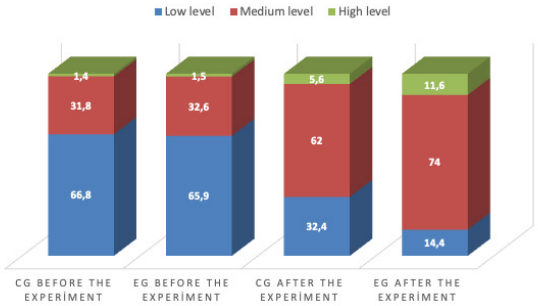
Results of the Comparative Analysis of the Summative and Control Stages of the Experiment for the Communicative Criterion



According to the motivation criterion at a high level, the increase in the experimental groups was 11.6%, in the control groups - 5.6% (Figure 6), and it was on average 62.0% and 74.0%, respectively.

Figure 6

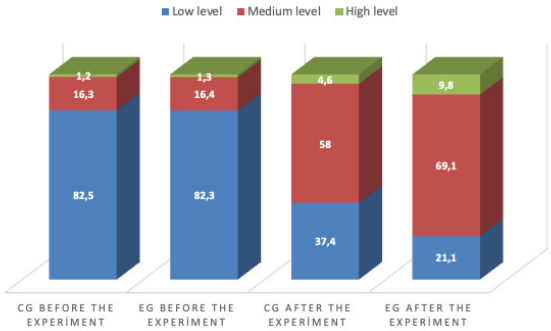
Results of the Comparative Analysis of the Summative and Control Stages of the Experiment for the Motivational Criterion



The difference in the experimental groups for the cognitive criterion at the high level of the criterion is 9.8%, and in the control groups - 4.6% (Figure 7), which on average is 69.1% and 58.0%, respectively.

Figure 7

Results of a Comparative Analysis of the Summative and Control Stages of the Experiment for the Cognitive Criterion



To calculate the value of the statistics after the experiment, we enter the designation corresponding to the one used in the formula for calculating the value of Pearson's chi-squared test, and make the necessary calculations (Table 6).

We obtain the statistical values for each criterion by substituting the values of the relevant variables into the formula for calculating the value of Pearson's chi-squared test (Table 7).

The results of the comparative analysis of the summative and control stages of the experiment (Table 8) showed a significant advantage of the developed methodical system of learning with the help of digital technologies (according to the averaged indicators), which is presented in Figure 8.

Table 6

Auxiliary Table for Calculating the Value when Comparing the Distributions of Teachers of the Experimental and Control Groups According to the Levels of Professional Competence after the Experiment

Sample	The number of teachers	The number of students with a high level	The number of students with a medium level	The number of students 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 activity criterion		
EG	n_1=134	Q_{11}=23	Q_{12}=102	Q_{13}=9
CG	n_2=130	Q_{21}=13	$Q_{2}2$=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

Table 7

The Criterion Statistics when Comparing the Distributions of Future Teachers of the Experimental and Control Groups According to the Professional Competence Levels after the Experiment

Readiness criteria				X^2_{ex} criterion statistics
	Sample	χ^2_{er}	χ^2_{cr}	Result
Motivational criterion	EG CG	13,96	5,99	$\chi^2_{excr\rightarrow} > \chi^2$
Cognitive criterion	EG CG	10,17	5,99	$\chi^2_{excr\rightarrow} > \chi^2$
Communicative criterion	EG CG	10,03	5,99	$\chi^2_{excr\rightarrow} > \chi^2$
Operational and activity criterion	EG CG	19,2	5,99	$\chi^2_{excr\rightarrow} > \chi^2$
Personality criterion	EG CG	7,94	5,99	$\chi^2_{excr\rightarrow} > \chi^2$
Level	Arithmetic mean	11,2	5,99	$\chi^2_{excr\rightarrow} > \chi^2$

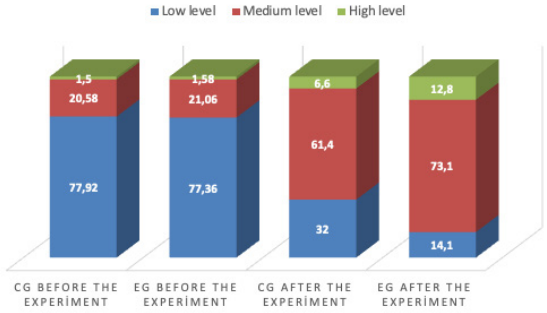
Table 8

Comparison of the Results of the Summative and Control Stages of the Experiment (as a Percentage)

Criteria	Group	CE	FE	Difference	CE	FE	Difference	CE	FE	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	- 34.0
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 activity	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 8

Results of the Comparative Analysis of the Formative Stage of the Experiment (According to Average Indicators)



A comparison of the values of the *ex* = 11.2 criterion, the calculated data of the conducted experiment and the critical *cr* = 5.99 with a 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 according to the levels of each criterion are statistically reliable and testify to the effectiveness of the use of digital technologies for the development of professional competence of future primary school teachers.

Discussion

The formative stage of the pedagogical experiment involved a comparative analysis of the students' performance in the control and experimental groups. As a result, the positive dynamics were recorded in both groups, however, the quantitative indicators of the criteria in the experimental group grew faster and with a greater difference compared to the change in the control group, both in each of the criteria and in average indicator. At a high level, the largest changes were observed in the experimental group for the operational criterion: the difference was 15.40% (against 7.90% in the control group). In our opinion, this is explained by the fact that students could additionally develop the acquired practical skills during quasi-professional activities thanks to the expansion of the content of the forms and methods of professional training with the involvement of digital learning. The smallest increase at a high level was recorded for the cognitive criterion: 8.5% in the experimental group and 3.4% in the control group. This is related to the practical focus of the developed training content and the use of the competency approach as the main one in the process of organizing experimental training. According to the average indicator at the high level, the difference in the experimental groups is 11.22% and in the control groups - 5.1%. A greater increase in the average indicator at the medium level was also recorded in the experimental groups, namely 52.04% (against 40.82% in the control groups).

The researchers such as Timotheou et al. (2023), Schraube (2022) found that the implementation of digital technologies in education has a significant impact on student learning. The same conclusions were drawn by Timotheou et al. (2023), who noted that the integration of ICT in schools affects not only student performance but also some other aspects related to the school and the parties concerned.

According to Keser et al. (2011), Shatri (2020), students can stay connected, obtain and share information, for example, in class groups, online and in virtual environments through the use of technological tools. We haven't studied this aspect, but the level of communication skills of EG students increased significantly compared to EG.

Baytak et al. (2011), Zaporozhchenko et al. (2022) found that the majority of students believe that the integration of technology into the curriculum plays an important role in improving their learning abilities. Integrating technology into education is also beneficial for students with special needs. Elshareif and Mohamed (2021) noted that the integration of technology in education enhanced student motivation and involvement in the educational process, which also confirms the results of the diagnostics of the motivational criterion of professional competence.

So, the results of the study indicate that the integration of digital technologies into the learning process contributes to the improvement of students' academic performance, especially in operational and medium-term planning. This emphasizes the importance of the development of digital education for improving the quality of education and preparing students for modern challenges.

Research Limitations

The main limiting factors of the study are the involvement of only full-time students in the diagnostics, and conducting of the experiment during one academic year.

Recommendations

For further development of the raised problem, we recommend developing a single diagnostic method for diagnosing the professional competence level of primary school teachers during professional training for the Master's degree.

Conclusions

Digital technologies, as well as information and communication tools are changing the way of learning and teaching. Professional training of future teachers should meet current requirements so that

graduates can implement these technologies in the educational process.

The analysis of the results of the formative stage of the pedagogical experiment confirmed the effectiveness of digital technologies for the development of professional competence of future primary school teachers. The advantages of digital technologies in the educational space are the individualization of the educational process, personal orientation. The advantages include minimization of paperwork, simplification of teaching and learning. Students develop more practical skills. The use of digital technologies makes it possible to bring education to a qualitatively new level characterized by the accessibility of knowledge.

The education is currently moving to a new level, where the priority is not only to fulfil the requirements of the programme, but also to take into account the students' interests and individual abilities. The use of digital educational technologies expands the students' horizons, opens up new opportunities for acquiring knowledge in the most structured and understandable form.

The promising areas for further research are studying the impact of the use of digital technologies for the development of information literacy and critical thinking.

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