

DEVELOPMENT OF DIGITAL COMPETENCES OF FUTURE TEACHERS

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***Abstract:** The article discusses the problem of development of digital competences of future teachers in the context of Digital Competence Framework for Educators (DigCompEdu). Particular attention is paid to the analysis of the European system of digital competences of teachers in order to adapt it to the national system of higher pedagogical education. The paper focuses on the study of the levels of Volodymyr Hnatiuk Ternopil National Pedagogical University students' digital competences formation. The authors reveal the peculiarities of the created method of formation and development of digital competences of teachers in terms of DigCompEdu.*

Keywords: digital competences, DigCompEdu, teachers, research, methodology for digital competences development.

INTRODUCTION

The increased attention to the problems of pedagogical education is resulting from the new civilizational challenges facing man and society and from the modernization of educational institutions in connection with the rapid development of digital technologies. Reformers in different parts of the planet are trying to define and formulate the digital competences necessary to ensure the preparation of the younger generation for life in the 21st century.

Thus, in a joint report on the implementation of the strategic framework for European cooperation in the field of education and training, the need for the formation of digital competences and positive contribution of digital technologies to teaching have been emphasized (Declaration on Promoting citizenship and the common values of freedom, tolerance and non-discrimination through education. Informal meeting of European Union education ministers 2015).

Understanding digital competences has undergone significant changes in recent years. For our study, we consider the definition of digital competence, which includes a sure, critical, responsible use and interaction with digital technologies for learning, work and public engagement (Ferrari 2013).

In particular, according to the most recent framework document (Proposal for a Council Recommendation on Key Competences for Lifelong Learning 2018), citizens of the modern information society have to:

- understand how digital technologies can support communication, creativity and innovation;
- understand general principles, mechanisms and logic underlying digital technologies;
- understand the possibilities and limitations of digital technologies;
- approach to credibility, reliability and impact of information and data from a critical standpoint;
- create, program and distribute digital content;
- manage and protect information, content, data and digital identities;
- work effectively with programs, devices, artificial intelligence and robots;
- understand legal and ethical principles associated with the use of digital technologies.

From our point of view, special attention should be paid to the ability to use digital technologies to support active citizenship and social integration, cooperation with others and creativity to achieve personal, social or commercial goals (Balyk & Shmyger 2018).

We note that teachers are active citizens of digital society, so their digital competences should be flexible enough to be relevant both now and in the near future. Considering this, there is a problem of restarting all pedagogical education and analyzing theoretical and practical approaches to the development of digital competences of future educators.

A comprehensive solution of this problem is possible providing the development of teachers' digital competences based on the DigCompEdu framework and its projection on the national education system. We also need to change university curricula, programs and teaching methods in accordance with the current state and trends of digital technologies development, and increase the level of digital competences of university professors.

The purpose of the article is to analyze the domestic and foreign experience of determining theoretical and practical aspects of the development of digital competences of future teachers. We aimed to study the level of students' digital competences formation in the context of the European Digital Competence Framework for Educators (DigCompEdu), and describe the developed methodology for developing their digital competences at the Volodymyr Hnatiuk Ternopil National Pedagogical University.

1. THEORETICAL BASIS OF THE STUDY

Scientists from many countries have been developing an approach to competency-based training as a modern teaching standard for teachers training. The categorical and conceptual apparatus of the competency-based approach is

considered in different scientific studies (Bykov & Ovcharuk 2017), (Morse, Barna, Kuzminskaya & Vember 2017), (Ovcharuk 2005), (Wolfe & Steinberg 2014), (Johnstone & Soares 2014). For example, the authors (Smirnova-Trybulska, Stec, Studenska, Noskova, Pavlova, Yakovleva & Delgando 2017) define competence as an individual potential to adapt to environmental conditions, to implement creative changes and to act effectively.

J. Gervais constructed an operational definition of competency-based education. In particular, CBE is defined as an outcome-based approach to education that incorporates modes of instructional delivery and assessment efforts designed to assess the mastery of learning by students through their demonstration of the knowledge, attitudes, values, skills and behaviors required for the degree sought (Gervais 2016).

Scientists consider the problem of identifying key competences in the field of digital education and teacher training (Crick 2008), (Smirnova-Trybulska 2007). The aim of the study (Svensson & Baelo 2014) was to determine teachers' understanding of digital competences for developing their future profession. The review (Pettersson 2018) focuses mainly on how digital competences in educational contexts have been regarded in international research over the past 10 years in terms of politics, organizational infrastructure and strategic leadership.

R. Hall, L. Atkins, and J. Fraser have reviewed a variety of frameworks (Hall, Atkins & Fraser 2014). These frameworks are structured around three or four levels, which tend to reveal a deficit model at the lower levels and determine critical digital engagement on the progress of the very basic requirements to the demonstration of expert, transformational skills, practices and knowledge. For example, the levels defined in the DigEuLit project (Martin & Grudziecki 2007) move from 'digital competence', generic skills and approaches to 'digital usage', the professional application of these skills and finally to 'digital transformation', where innovation and creativity occurs.

The model for integrating digital competences into the professional development of teachers is analyzed in the study (Pozos 2010, UNESCO 2008). The model contains a framework of 7 digital competences, 78 units of digital competences distributed over three levels of competences development: Basic Knowledge, Knowledge Deepening and Knowledge Generation.

The work (Balyk & Shmyger 2017) reveals the process of forming teachers' digital competences at the smart university as well as defines organizational and pedagogical conditions, principles and pedagogical methods of their development and presents a three-dimensional model for the formation of digital competences in the context of creating new knowledge.

2. THE PRESENTATION OF MAIN RESULTS

2.1. Digital competences. Teacher Training

Modern society should promote the development of digital competences necessary for lifelong learning. Teachers play an important role in the process of mastering these competences by the younger generation. Therefore, appropriate conditions must be provided to properly motivate and train future teachers. Without professional growth and continuous training, teachers will not be able to integrate correctly the topic of digital competence into the context of their disciplines.

Reform of higher education in Ukraine requires changes in the system of training of young people. These changes, along with other social and economic challenges, require an adequate response from higher education. Realizing the importance of a teacher in developing students' digital competences, we offer a study that aims to promote the development of digital competences of future educators.

To implement our research, we have focused on the digital competences identified by the European Digital Competence Framework for Educators. DigCompEdu outlines the tools needed to increase teachers' digital competences level.

The DigCompEdu framework involves a common EU approach to defining and describing the main areas of teachers' digital competences and provides a common focus at the European level. The framework views six different areas of competences.

The first area is focused on the professional environment. The second one is related to digital resources search, creation and exchange; the third area is related to the management and use of digital teaching tools and the fourth one deals with digital tools and strategies to improve evaluation. The fifth area is connected with the use of digital tools for expanding pupils' capacities. The sixth area concerns students' acquisition of digital competences. Areas 2 to 5 form the pedagogical core of the framework. They detail the competence that teachers need to develop in order to exercise effective, inclusive and innovative learning strategies using digital technologies (DigCompEdu 2018).

2.2. Research methods

We will present a methodology for the preparation and conduct of the research, the experimental base and its participants, and indicate the levels of digital competence and the indicators by which they were evaluated

During the experiment, we used a set of research methods, namely:

theoretical – analysis of scientific and educational-methodical literature, official documents of the European Union and the Ministry of Education and

Science of Ukraine to determine the theoretical foundations of the problem solution;

empirical – observation to determine the state of levels of formation of digital competences of future teachers; development of experimental research methodology; detecting the effectiveness of experimental work;

a pedagogical experiment, which allowed to investigate the real influence of the developed methodology on the process of preparation of future teachers;

statistical methods of mathematical processing of scientific data for the analysis and interpretation of research results.

The research was carried out in the course of the following stages:

1. Identification of indicators and levels of digital competence.
2. Creating a questionnaire. Formulating allegations that measure the indicators value and levels of digital competence.
3. Carrying out the ascertaining stage of the experiment in order for students to self-assess their level of formation of digital competences.
4. Adaptation of university educational programs in the field of information technologies to the DigCompEdu Framework, development of a methodology for increasing the level of students' digital competences.
5. Carrying out the formative stage of the experiment so that students can self-assess their level of the formation of digital competences.
6. Statistical processing of results and summing up.

First-year students assisted with the study. The survey was conducted among the students so they self-assessed their level of the formation of digital competences. A control group (CG) of 53 students and an experimental group (EG) of 54 students were selected.

At the initial stage of the study, a questionnaire was created based on the Digital Competence Framework for Educators (DigCompEdu) in order to determine the level of formation of the digital competences of future teachers. It assesses five areas of competences: professional development, digital resources, student learning and assessment, students' digital competence formation, teacher in the information society with 22 descriptors which are: organizational communication, professional cooperation, reflexive practice, continuous digital professional development, digital resources selection, creation and change of digital resources, management, protection and exchange of digital resources, training, management of learning process, organization of joint training, organization of reflexive learning and self-control, evaluation strategies, analysis and interpretation of digital data, feedback and planning, accessibility and inclusion, differentiation and personalization, active engagement of students,

interactive and active student learning, information and literacy in the media, digital communication and collaboration, digital content creation, responsible use of digital content, digital problem solving.

Therefore, the questionnaire generally contains 22 questions pertaining to each of the descriptors. The evaluation was conducted on a four point scale (1 – low, 2 – medium, 3 – high, 4 – creative). The following question template was used: «Evaluate, please, what is your skill level...»? Here are some examples of questions from the questionnaire: «Evaluate, please, what is your skill level in digital student assessment strategies»? «Evaluate, please, what skill level in digital technology you have for the purpose of organizing student cooperation»?

2.3. Research results

Let us outline the main results of the study. The ascertaining stage of the experiment was conducted in control and experimental groups in the beginning of the first semester of computer studies learning. Summarizing the data of the ascertaining stage of the experiment, the total indicators of the levels of formation of digital competences of students were calculated. Their arithmetic mean values are given in Table 1.

Table 1.
General indicators of the level of students' digital competence formation before the experiment (%)

Digital competence	Levels							
	low		Medium		high		creative	
	CG	EG	CG	EG	CG	EG	CG	EG
Professional growth	40,9	41	37,2	37,4	13,5	13,2	8,4	8,4
Digital Resources	12,2	12,3	45,6	45,5	36,5	37,2	5,7	5
Training and assessment of students	40,3	40,6	38,5	39,2	15,8	16,4	5,4	3,8
Students' digital competence formation	34,3	35,8	39,7	40,1	18,4	19,3	7,6	4,8
Teacher in the information society	18,1	19,3	34,5	36,4	38,6	39,5	8,8	4,8
Average value	29,16	29,8	39,1	39,72	24,56	25,12	7,18	5,36

Source: Own work

We should note that the results of the ascertaining stage of the experiment gave the opportunity to conclude on the quantitative and qualitative characteristics of the formation of the digital competences of future teachers in the process of studying digital technologies at the pedagogical university.

Professional growth	37,5	23,5	39,3	51,2	14,2	15,4	9	9,9
Digital Resources	11,4	9,5	44,3	45,5	37,6	37,2	6,7	7,8
Training and assessment of students	38,2	18,2	39,4	49,2	15,8	25,1	6,6	7,5
Students' digital competence formation	32,5	14,9	39,9	42	19,1	29,4	8,5	13,7
Teacher in the information society	17,8	8,6	33,7	38,5	39,2	40,9	9,3	12
Average value	27,48	14,94	39,32	45,28	25,18	29,6	8,02	10,18

Source: Own work

The results of the experimental work are illustrated using histograms (Figure 1, 2). Their analysis shows that after the experiment there have been positive changes in the formation of digital competences in EG of future teachers because of the application of the developed teaching methodology. In contrast, minor changes were recorded in CG.

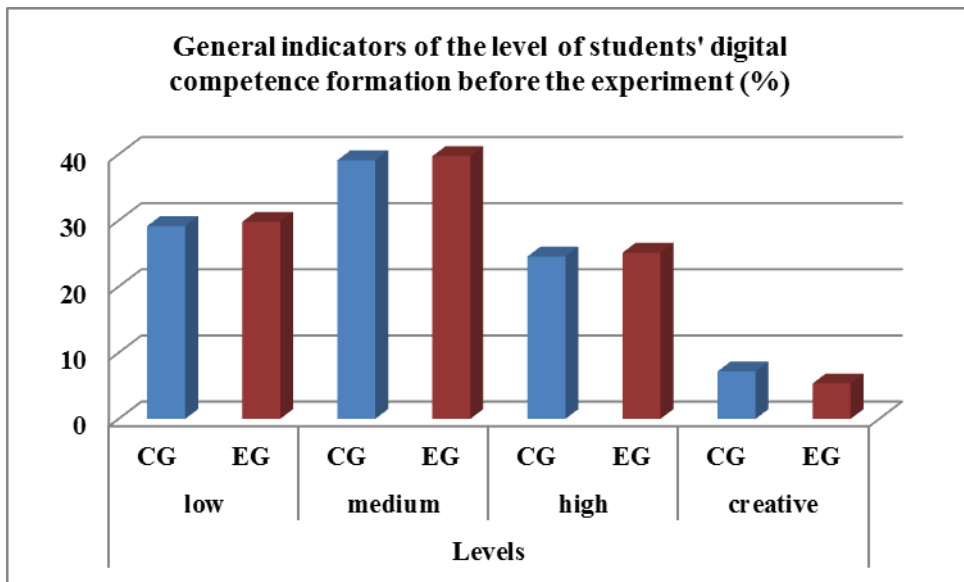


Figure 1. General indicators of the level of students' digital competence formation before the experiment

Source: Own work

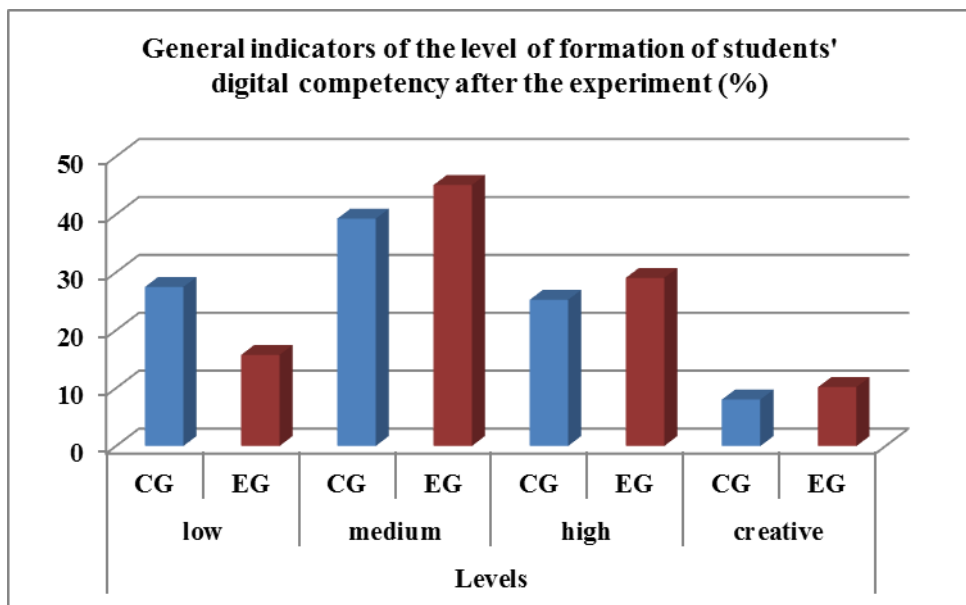


Figure 2. General indicators of the level of students' digital competence formation after the experiment

Source: Own work

To test the null hypothesis H_0 for the absence of significant differences between the obtained indicators of levels of digital competence in EG and CG after the formative stage of the experiment, we use the statistical criterion χ^2 (Pearson criterion). To achieve this, we will calculate the empirical value of the criterion according to formulas (1) and (2) and compare it with the critical according to statistical tables.

$$\chi^2_{emp} = \sum_{i=1}^n \frac{(f_{ei} - f_{ci})^2}{f_{ci}} \quad (1),$$

where f_{ei} is the relative frequency of e -value (experimental) on the i -th interval, f_{ci} is the relative frequency of c -value (control) on the i -th interval.

The relative frequency of f_{ei} on the i -th interval is determined by the formula

$$f_i = \frac{F_i}{\sum F_i} * 100\% \quad (2),$$

where F_i is the frequency of occurrence of value (e – experimental, c – control) on the i -th interval, and acquires values from 1 to n (in our case $n = 4$, which is the number of intervals). The change in the levels of the formation of digital

competences and the calculation of the empirical value of the criterion χ^2 are presented in Table 3.

Table 3.
The change in the levels of the formation of digital competences and the calculation of the empirical value of the criterion χ^2

№ of interval	Relative frequency $f_e, \%$	Relative frequency $f_c, \%$	$f_e - f_c$	$(f_e - f_c)^2$	$\frac{(f_e - f_c)^2}{f_c}$
1	14,94	27,48	-12,54	157,25	5,7224
2	45,28	39,32	5,96	35,522	0,9034
3	29,6	25,18	4,42	19,536	0,77587
4	10,18	8,02	2,16	4,6656	0,58175
All					$\chi_{emp}^2 = 7,98341$

Source: Own work

For the degree of freedom $n-1 = 3$ according to the table, at the level of significance $\alpha = 0.05$ we find that $\chi_{crit}^2 = 7,8$. We got that $\chi_{emp}^2 > \chi_{crit}^2$.

Thus, the null hypothesis is rejected. Instead, an alternative hypothesis is adopted, namely: the differences between the obtained indicators of the level of the formation of digital competences in CG and EG are not random (with a probability of 95%), which justifies the effectiveness of our proposed methodology.

CONCLUSION

The development of future teachers' digital competences is a topical issue of theory and methodology of education. The methodology for the formation and development of digital competences should be considered in terms of integration of the European Digital Competence Framework for Educators (DigCompEdu) and national standards and training programs.

In the context of developing digital competences of teachers, a methodology based on an open concept of learning – e-learning technology, collaborative learning, transdisciplinary STEAM projects, case study, design thinking – has been developed.

The conducted experimental research testifies to the effectiveness of our proposed methodology. This study contributed to the change in university curricula and teacher training programs and the development of their digital competences. The modernization of the University's curriculum based on the DigComp standard has contributed to the creation of innovative educational initiatives.

The long-term goal of this study is to facilitate the development of a methodological framework for the integration and development of digital

competences in teacher training programs and in developing relevant methodological recommendations.

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