Development of informational and research competence of postgraduate and doctoral students in conditions of digital transformation of science and education

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Abstract. Digital transformation of education and science puts forward new requirements for training of graduate and doctoral students, in particular for development of informational and analytical competence. It is described in international documents governing scientific field. Analysis of digital systems and consideration of their services allows us to say that their existing list and functionality can be used to develop informational and research competence of postgraduate and doctoral students. It is confirmed that important role in development of informational and research competencies of postgraduate and doctoral students is given to digital technologies, in particular, to digital open systems. Their use contributes to improving and expanding opportunities in research, presentation of research results and image of the researcher and institution. Digital society requirements to informational and research competence of postgraduate and doctoral students are defined and described. They include: readiness and ability to carry out research activities; ability to search and select necessary information and data, their transformation, storage and transmission using digital technologies; ability to critically evaluate found information (check their accuracy, timeliness, expediency); ability to perform scientific research (organization, planning, conducting) with use of digital technologies. Course of experimental work is presented; the obtained results are given and their interpretation is carried out. Fisher's angular transformation was applied in order to confirm reliability of obtained results of experimental study. Experimental verification of the proposed methodological system of using digital systems in postgraduate and doctoral students training, aimed at the development of information and research competence confirmed its effectiveness and pedagogical feasibility.

1. Introduction

Digital transformation processes of society and improvement of digital technologies changed way of organizing and conducting research and contributed to development of digital science. The

international document “Plan S” [1]emphasizes that from 2021 all scientific publications on the results of research funded by public or private grants, provided by national, regional and international research councils and funding bodies, should be published in open access journals, on open access platforms or directly accessible through open access to storage without interference. Openness of publications and research results is the main goal for development of open digital science among basic principles of open science.

The Concept of Development of Digital Economy and Society of Ukraine [2] emphasizes that development of scientific digital infrastructure (for scientific and educational institutions) is also crucial to ensure open access to scientific data and knowledge, further commercialization of research, innovation, products and services. New knowledge and developments carried out by financing from the state budget should be openly available and become property of society as a whole. Also, one of the important elements of the European Digital Single Market and part of the Open Innovation – Open Science – Openness to the World paradigm is development of the European Open Science Cloud and European Data Infrastructure.

Implementation of Ukraine’s strategy for integration into the European research environment and the country’s prosperity is impossible without development of human potential, in particular researchers training as the main drivers of the nation’s progress. “Increasing of high-tech industries, creating favorable conditions for internationalization of education and science, mobility and continuing education of scientists, providing information and technical resources for research, development of modern information and communication technologies should be prior mission of the state” [3].

Currently, an important factor that determines development of society in modern conditions is staffing of science and higher education. Therefore, it is important to determine strategic directions of development of scientific personnel training system of the highest qualification. This is determined by the fact that development of scientific personnel training system is an integral factor in scientific and technological progress of society. Mastering modern achievements in the development of digital technologies determines new tasks for highly qualified specialists training, modernization of educational and qualification levels structure, requirements updating for the third degree - Doctor of Philosophy. The effective approaches search to scientific personnel training aimed to achieve science and education in modern world levels and growth of intellectual potential of society have special relevance [4].

Digital transformation of science and education requires updating and modernizing process of preparing postgraduate and doctoral students. Introduction of digital systems, and their use both for dissertation research and for management process organization of training graduate and doctoral students is prior and important. Therefore, it is important to analyze and substantiate digital society requirements to the competencies of graduate and doctoral students as professionals who will work in the new technological era. And it is the development of research and digital competencies of graduate and doctoral students that is one of the key aspects for outlined problems solution.

2. Literature review

The authors selected, summarized and systematized publications in the following areas during analysis of scientific literature on the main topic of this study:

- features of digital technologies development and implementation into the educational process ([5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27]);
- digital systems application for scientific research ([28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45]);
- features of development of information-analytical, information-research competence of post-graduate students, scientific and scientific-pedagogical workers ([46], [47], [48], [49], [50], [51], [52]), etc.;

- training problems of postgraduate and doctoral students ([4], [31], [46], [47], [48], [49], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63]).

However, there was no purposeful development of information and research competencies of graduate and doctoral students using digital systems in the publications analyzed above. The author's methodological system of digital systems using in the training of postgraduate and doctoral students was developed and proposed. It directly affects development of information and research competencies.

The purpose of the study is to describe course of research and experimental work on the development of information and research competence of postgraduate and doctoral students and summarize results of pedagogical experiment.

3. Research results

The authors team [42] emphasizes that digital transformation processes of education and science, international initiatives to evaluate and open access to research results encourage search, selection and wider use of statistical, information and analytical services of open digital archives, journals, monographs, scientometric platforms, bibliographic databases and other educational and scientific systems for evaluating the results of scientific research [42]. Digital open science involves use of Web-based systems to support and develop it. Such systems are, first of all, Web-based systems for monitoring of publication, dissemination and use of research results. Methods of data collection and analytical processing used earlier can no longer meet the urgent needs of science and education in the period of society digital transformation. Therefore, the use of digital technologies for information and analytical support of research is relevant [19].

Currently, the most important area of modern scientific thought is integration of higher education and science in order to prioritize the development of new scientific research aimed at the formation of developed civil society. Changes in the educational activities of Ukraine in recent years, growth of professional, intersectoral and other types of labor mobility require thorough process review of highly qualified scientific personnel training [1]. Today, many universities and research institutions have licenses to train graduate students, but use of digital systems in the teaching of graduate and doctoral students is not fully implemented. Also, use of these systems is relevant and forced measure, as general public will be able to get acquainted with scientific results, which will affect scientific image formation of graduate and doctoral students and image of institution where the researcher studies or works [4]. Indeed, professional development of specialists in modern conditions is impossible without free orientation in the digital space, ability to quickly perceive and process large amounts of information, constantly update their knowledge, expand range of necessary skills and abilities. This is increase in competence level associated with ability to find necessary information, analyze it, structure and qualitatively transform and use it in their own professional activities [52]. Therefore, digital systems use for graduate and doctoral students training is mandatory and important component for development of informational and research competence.

3.1. Informational and research competence of postgraduate and doctoral students: criteria and indicators

Development of informational and research competence of scientific and research and pedagogical workers is systematic and natural process of progressive changes in professional competence of individual in accordance with digital society needs. It provides ability to acquire new knowledge, improve skills, gain new experience in digital technology. In the collective work [51] the concept of "informational-research competence (ID-competence) of scientific and scientific-pedagogical workers" is defined as ability of individual on the basis of acquired knowledge, skills, abilities and acquired experience to use information-digital technologies for organization, planning, conducting own research, as well as to evaluate and implement their results and monitor.

Based on analysis of scientific sources and personal experience the concept "informational and research competence of postgraduate and doctoral students" is defined as readiness and ability of the

individual on basis of acquired knowledge, skills, abilities and acquired experience to carry out research, ability to search and select their transformation, storage and transmission using digital technologies, ability to critically evaluate found information (check their accuracy, timeliness, feasibility), ability to perform research (organization, planning, implementation) using digital technologies. Also, the authors of this study identified criteria and indicators of information and research competence of graduate and doctoral students, which are described in table 1.

Table 1. Criteria and indicators of informational and research competence of postgraduate and doctoral students.

Criterion	Indicator
Value-motivational	awareness of need to use digital technologies for research; systematic use of digital technologies for scientific research; motivation to deepen knowledge, skills and abilities to work with digital technologies for research activities
Cognitive	knowledge of basic concepts, methodology of research activities; knowledge of mathematical and statistical methods of processing research data; awareness of available digital technologies to support research
Activity	ability to analyze current research; ability to use digital technologies for research planning; skills mastery in working with scientific literature and ability to compile bibliographic lists; ability to use digital technologies for statistical data processing and presentation of results; skills of safe application of digital technologies in searching and storing data process; ability to use software and hardware for data protection; ability to use open digital scientific and educational systems to search and store information; ability to select optimal digital technologies at each stage of scientific research; ability to search for like-minded people on scientific ideas, innovations and their implementation; skills to carry out scientific communication with the use of digital technologies; skills to apply digital technologies to solve a specific research problem
Evaluative-reflexive	self-reflection, self-assessment of own research activity and received scientific results, choice of actual directions of further scientific researches

Development levels of informational and research competences of postgraduate and doctoral students were identified in accordance with the listed above indicators:

- *high level* implies presence of deep knowledge of basic concepts, methodology of research activities, mathematical and statistical methods of processing research data; systematic use of digital technologies for scientific research; motivation to deepen knowledge, skills and abilities to work with digital technologies for research activities; awareness of available digital technologies to support research; ability to use digital technologies for research planning; mastery of skills in working with scientific literature and the ability to compile bibliographic lists; ability to use digital technologies for statistical data processing and presentation of results; safe application skills of digital technologies in searching and storing data process; ability to use open digital scientific and educational systems to search and store information; ability to select optimal digital technologies at each stage of scientific research; ability to search for like-minded people on scientific ideas, innovations and their implementation; skills of scientific communication with use of digital technologies; self-reflection and self-assessment skills of own research activity and received scientific results, choice of actual

directions of the further scientific researches; focus on achieving a high level of information and research competence;

- *sufficient level* implies presence of knowledge about basic concepts, methodology of research, mathematical and statistical methods of processing research data; inconsistency in digital technologies for research; importance understanding of digital technologies using to support research; readiness to use digital technologies for research planning; mastery of skills in working with scientific literature and the ability to compile bibliographic lists; readiness to use digital technologies for statistical data processing and presentation of results; safe use of digital technologies in the process of searching and storing data; readiness to use open digital scientific and educational systems for search and storage of information; readiness to select optimal digital technologies at each stage of scientific research; skills of scientific communication with use of digital technologies; readiness for self-reflection and self-assessment of one's own research activity and its results; readiness to increase level of information and research competence;
- *low level* implies shallow knowledge of the basic concepts, methodology of research, mathematical and statistical methods of processing research data; lack of motivation to use digital technologies for research; weak motivation to deepen knowledge, skills and abilities to work with digital technologies for research activities; poorly developed digital technology skills for research planning; poorly developed skills of working with scientific literature and compiling bibliographic lists; weak orientation in the existing open digital scientific and educational systems for search and storage of scientific information; lack of motivation to select optimal digital technologies for each stage of research; weakly expressed skills of scientific communication with use of digital technologies; lack of motivation for self-reflection and self-assessment of one's own research activity and its results; unwillingness to increase the level of information and research competence.

3.2. Organization, conduction and results of pedagogical experiment

Pedagogical experiment was organized and conducted to the pedagogical feasibility and effectiveness of the developed methodological system aimed at developing the information and research competence of graduate and doctoral students. The pedagogical experiment involved scientists, research and teaching staff, management staff, graduate students and doctoral students from seven universities and one research institution in Ukraine. Totally 280 people were involved in the research and experimental work, 222 postgraduate and doctoral students and 58 scientific and pedagogical workers. They were involved in various stages of the pedagogical experiment. The experiment lasted during 2014-2020 in several successive stages.

I. Stage (searching) 2014-2017. At this stage institutions for research and experimental work were identified, namely: Institute of Information Technologies and Learning Tools of NAES of Ukraine (1), Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University (2), Zhytomyr Ivan Franko State University (3), National Aviation University (4), National Pedagogical Dragomanov University (5), Drohobych State Pedagogical University of Ivan Franko (6), Kryvyi Rih State Pedagogical University (7) and Bogdan Khmelnitsky Melitopol State Pedagogical University (8).

A questionnaire of the teaching staff and management of universities and research institutions that train graduate students was conducted. The state of readiness and competence for use of digital scientific and educational systems in the training of graduate and doctoral students was determined. To this end, 58 people (teachers, supervisors (consultants) and management staff) providing training for graduate and doctoral students were invited to undergo interviews. It was determined that 100% of respondents use digital open systems and technologies in the training of graduate and doctoral students summarizing results of the questionnaire. But when it was proposed to list which ones, only 50% named: scientometric databases, electronic libraries, ESD, specialized programs, cloud services and etc.; the other 50% named: e-mail, electronic social networks, messengers: Viber, Telegram, Skype; only 30% of respondents use digital open systems when teaching their subject to graduate students;

100% agreed to make more active use of digital systems and technologies in the training of graduate and doctoral students.

Also, partial testing of author's methods was carried out during seminars and master classes for postgraduate and doctoral students. Three authors of this study have organized and conducted on the basis of the Institute of Information Technologies and Learning Tools of NAES of Ukraine All-Ukrainian methodological seminar for young scientists "Information and communication technologies in education and research" since 2010. Postgraduate and doctoral students from various universities and research institutions of Ukraine regularly take part in this seminar. The seminar was held 8-4 times a year. Number of seminar participants was 15-35 people. Materials of the conducted seminars and audio recordings are placed in the Electronic library of NAPS of Ukraine: 2014 [64], 2015 [65], 2017 [66].

II. Stage (ascertaining) 2017-2018 years. Institutions (experimental base) were specified and experimental (EG) and control (CG) groups were formed among postgraduate and doctoral students to participate in the pedagogical experiment. The distribution of participants in the pedagogical experiment (postgraduate students and doctoral students) on CG and EG are presented in table 2.

Table 2. Criteria and indicators of informational and research competence of postgraduate and doctoral students.

Criterion	**Indicator**				
	1	**2**	**3**	**4**	**Total**
EG	16 p +4 d	46 p +4 d	24 p +2 d	14 p	110
CG	16 p +4 d	50 p +2 d	22 p +2 d	16 p	112
					222

The CG included postgraduate students who studied according to the traditional system provided in experimental institutions, as well as doctoral students. The EG included postgraduate students whose education involved introduction of the author's methodological system, and doctoral students were invited to attend training seminars and master classes.

Levels of information and research competencies development of postgraduate and doctoral students were determined (statement section). Postgraduate and doctoral students were asked to fill questionnaires and take tests in electronic or printed form. They were asked to independently determine development level of information and research competencies. The questions in the questionnaires were related to certain criteria and indicators of information and research competencies and were aimed to check level of their development. Each question had certain rating scale from 1 to 3 points, or required to enter your own answer. All answers were then summed in accordance with evaluation scale. It determined level of certain criterion manifestation. And in addition, there was pedagogical observation during interim reports of postgraduate students and doctoral students (intermediate certification, reporting at meetings of departments, divisions, speeches at methodological seminars and conferences).

It was also generalized results of development level assessing of information and research competence in CG and EG on all criteria and indicators. The average values in % for each development levels of (high, medium, low) in relation to the number of graduate and doctoral students in CG and EG are given in table 3.

Let's describe in detail results of development of information and research competence in CG and EG on all criteria and indicators (statement section). According to the value-motivational criterion, the following distribution was: "high" level – 30.7% in CG and 31.3% in EG, "sufficient" level – 54.6% in CG and 54.7% in EG, "low" level – 14.7% in CG and 14% in EG. According to the cognitive criterion – at "high" level was 14.7% in CG and 14.6% in EG, at sufficient" 46% in CG and 44.7% in EG, at "low" 39.3% in CG 40.7% in EG. The following results were recorded according to activity

criterion: at the “high” level 25.1% in the CG and 25.1% in the EG, at the “sufficient” 49.6% in the CG and 49.8% in the EG, at the “low” level 25.3% in CG and 25.1% in EG. The following distribution was according to evaluation-reflexive criterion: at the “high” level 6% in CG and 6% in EG, at “average” 44% in CG and 42% in EG, at “low” level 50% in CG and 52% in EG. It was determined that significant part of postgraduate and doctoral students developed information and research competence at “sufficient” and “low” levels due to result of distribution comparing of postgraduate and doctoral students according to three-level evaluation system. Therefore, we believe that it is necessary to carry out purposeful development of information and research competence of postgraduate and doctoral students according to the author’s methods.

Obtained quantitative results during implementation of ascertaining sections of development levels of information and research competence of postgraduate and doctoral students were also statistically processed using the Fisher's angular transformation. Obtained result proves that differences between the indicators in CG and EG in the development of information and research competence during the statement are absent, and groups are equivalent.

Table 3. Development levels of information-research competence criteria of postgraduate students and doctoral students in CG and EG (statement and control section).

The name of the criterion	**Group**		**Commentary**		
			High, %	**Sufficient, %**	**Low, %**
Value-motivational	CG	before	30,7	54,6	14,7
		after	31,3	56	12,7
	EG	before	31,3	54,7	14
		after	51,3	48,7	0
Cognitive	CG	before	14,7	46	39,3
		after	16	50,7	33,3
	EG	before	14,6	44,7	40,7
		after	28,7	61,3	10
Activity	CG	before	25,1	49,6	25,3
		after	27,1	50,5	22,4
	EG	before	25,1	49,8	25,1
		after	41,3	56,4	2,3
Evaluative-reflexive	CG	before	6	44	50
		after	6	48	46
	EG	before	6	42	52
		after	18	56	26

III. Stage (formative) 2018-2019. The formative stage of the pedagogical experiment was carried out after statement sections in CG and EG. At this stage there was experimental test of the methodological system effectiveness of digital systems using during training of postgraduate and doctoral students and there was a purposeful process of developing information and research competencies of postgraduate and doctoral students. Components implementation of the author’s methodological system included:

1. Consultations, seminars-trainings for lecturing staff and management of universities and research institutions were held.
2. Disciplines were taught to graduate students.

3. Seminars-trainings and master-classes for postgraduate and doctoral students were held.

In order to ensure equal conditions during the pedagogical experiment, the following features were observed: training in CG and EG was carried out by the same teachers if possible; competencies development of postgraduate and doctoral students in CG and EG was carried out in statistical equivalence. The training of postgraduate and doctoral students in EG was provided according to the author's methods, and the training of CG participants was carried out according to traditional methods. The pedagogical experiment results showed an increase in development levels of informational and research competencies of postgraduate and doctoral students, provided that they are actively introduced digital systems and specially developed methodological system into the training.

The author's methodological system was implemented in universities and research institutions directly by the authors of this research, and the management and teaching staff of these institutions were involved. Important component of the methodological system was the author's set of seminars and workshops with digital systems use. It was aimed to develop informational and research competencies of postgraduate and doctoral students. After completion of the formative stage of the pedagogical experiment, Assessment of development levels (control section) of informational and research competencies of postgraduate and doctoral students was re-performed according to special diagnostic tools after completion of the formative stage of the pedagogical experiment. For example, photos in figure 1 are taken after the pedagogical experiment on the basis of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University.

Figure 1. The pedagogical experiment on the basis of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University.

IV. Stage (control) 2020 year. Assessment of development levels of informational and research competence of postgraduate and doctoral students was performed according to each of the developed criteria at this stage. Table 3 presents generalized (averaged) quantitative results of development of informational and research competence of postgraduate and doctoral students on all criteria (control section). Also, the comparative distribution of levels and criteria of informational and research competence of postgraduate and doctoral students in EG and CG at the beginning and end of the pedagogical experiment is presented in the form of histogram in figure 2.

Following conclusions were made after analyzing the data from table 3 and figure 2: there was an increase in number of postgraduate and doctoral students in EG compared to the number of CG by all criteria as result of the introduction of the author's methodological system in the training of graduate

and doctoral students. The following redistribution took place after formative stage of the pedagogical experiment: according to the value-motivational criterion – 0% in EG and 12.7% in CG had "low" level of development of informational and research competence. According to the cognitive criterion - at "low" level was 10% in EG and in 33.3% CG. According to the activity criterion "low" indicators were recorded: 2.3% in EG and in 22.4% CG. According to the evaluation-reflexive criterion, 26% of EG and 46% of CG were at a "low" level. Also, assessment of development levels of informational and research competencies of postgraduate and doctoral students after the formation stage of the pedagogical experiment showed some changes in the participants of the CG. These changes could be more significant if the author's methods for purposeful development of information and research competence would implement. The control section results in EG and CG showed that the participants of EG had higher results in development of informational and research competencies than the participants of CG.

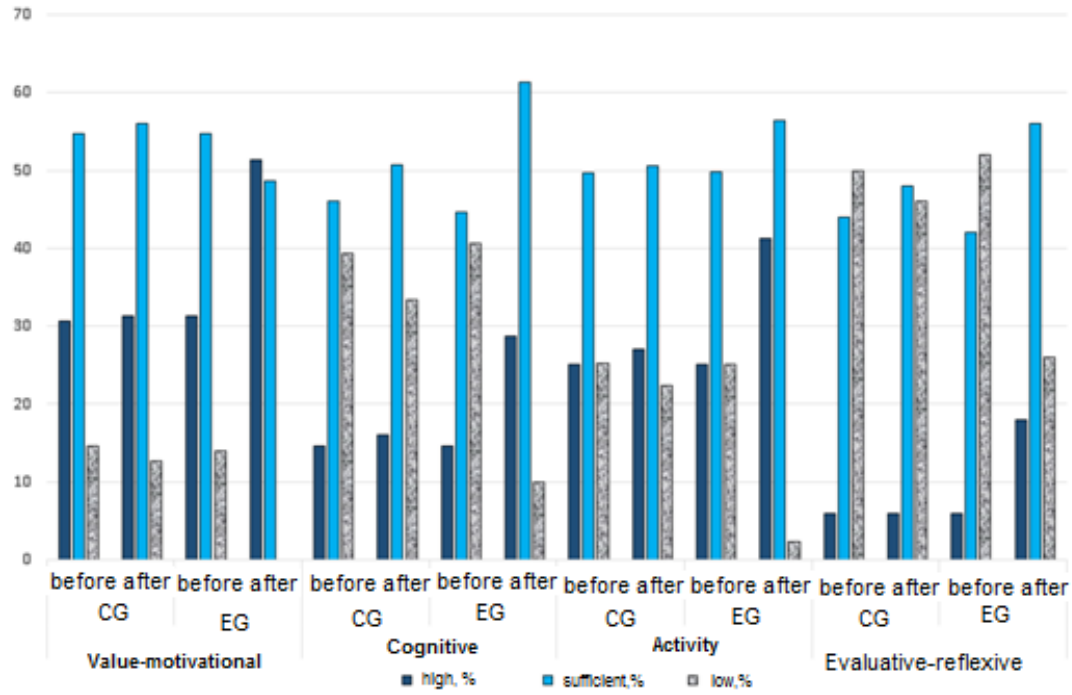

Figure 2. Comparative distribution according to levels and criteria of informational and research competence of postgraduate and doctoral students in EG and CG (statement and control section).

Changes in development of information and research competence are determined as a result of introduction of experimental methodical system in preparation of postgraduate and doctoral students. It is presented in Figure 3. These changes are: number of postgraduate and doctoral students with "low" level decreased in EG from 32,94% to 9,59%, respectively, the number of postgraduate and doctoral students with "sufficient" level increased from 47.79% to 55.59% for EG; number of postgraduate and doctoral students with "high" level also increased from 19.27% to 34.82% for EG. The developed author's methodological system confirmed its effectiveness and pedagogical expediency, because in EG a large number of graduate and doctoral students reached "high" and "sufficient" levels of information research competence. It is showed during comparison and interpreting the data of observational and control sections in EG and CG.

Following conclusions were made after analysis of quantitative results of the development of information and research competence: the number of postgraduate and doctoral students with a "low" level decreased in EG from 32.94% to 9.59%; "sufficient" level increased from 47.79% to 55.59% for EG; the number of graduate and doctoral students with "high" level also increased from 19.27% to

34.82% for EG. Therefore, we believe that the developed methodological system contributed to qualitative changes in graduate and doctoral students, namely growth of development levels of information and research competence.

Also, statistical processing of obtained quantitative data was performed. It was determined whether there are differences between development levels of information and research competence in EG and CG after the control section using the Fisher's angular transformation. It was confirmed that there are statistically significant differences in these samples after the control section. It was concluded that author's methodological system is more pedagogically appropriate and effective than the traditional one.

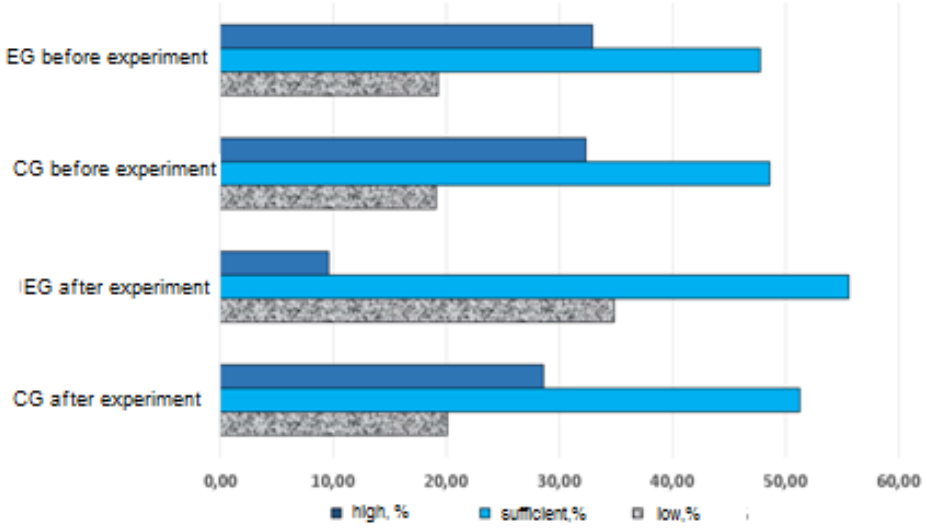

Figure 3. Comparative histogram of growth levels of development of informational and research competence of postgraduate and doctoral students in CG and EG after the formative stage of pedagogical experiment.

4. Conclusions

Process of society digital transformation puts forward new requirements for the competencies of postgraduate students and scientists, in particular for digital technologies use for scientific activities. It directly affects development of informational and research competence. It is confirmed that important role in development of informational and research competencies of postgraduate and doctoral students is given to digital technologies – digital open systems. Their use contributes to improving and expanding opportunities in research, presentation of research results and image of the researcher and institution. Also, use of outlined tools for research will significantly reduce financial and time costs and promote faster dissemination of scientific results.

The digital society requirements to the information and research competence of postgraduate and doctoral students are determined and described. They include:

- willingness and ability to carry out research activities;
- ability to search and select necessary information and data, their transformation, storage and transmission using digital technologies;
- ability to critically evaluate found information (check their accuracy, timeliness, feasibility);
- ability to perform scientific research (organization, planning, conducting) with use of digital technologies.

Thus, the author's methodological system was the most effective for postgraduate and doctoral students with "low" level of information research competence. They were able to reach higher level, so number of those who had a "low" level decreased due to acquired skills and knowledge. Significant

shift in distribution of postgraduate and doctoral students and increase in number of those who had "sufficient" and "high" levels of information research competence was observed where the author's methodological system was implemented. It confirmed its pedagogical feasibility. Quantitative data were statistically processed using Fisher's angular transformation at different stages of the pedagogical experiment. So, experimental verification of the author's methodological system aimed to develop informational and research competence of postgraduate and doctoral students confirmed its effectiveness and pedagogical expediency.

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