Development of Graphic Culture of Students in the Digital Educational Space

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Abstract: The importance of the use of digital technologies in the educational system provides new opportunities for the digitalisation of the learning process and new solutions in the field of teaching methods. The article presents the results of the analysis of scientific works dealing with the issues of formation and development of graphic culture of students at different levels of education and methodological materials related to new digital solutions using digital services, thanks to which the subject material can be considered as a mathematical model. Priority computer programs for the use of digital solutions in the study of mathematical disciplines at higher educational institutions will be identified, thanks to which it will be possible to determine the popularity of the use of a particular program for recording the results of education on the basis of objective data.

1 INTRODUCTION

The relevance of research on the formation of graphic culture of students in different educational systems is determined by the strategy of development of Russian education, namely, the National Educational Doctrine of the Russian Federation and the Concept of Modernization of Russian Education. "In dynamic and unpredictable conditions, successful work of any higher educational institution is impossible without continuous improvement of its activities aimed at increasing the quality of educational, scientific, informational and other services" (Myalkina, 2019).

In the present realities graphic culture has become a central phenomenon of the general culture of modern man, in which the information representation in the form of various graphic signs, symbols, dependencies, which carry the functions of visibility, content and economy, is increasingly used.

Significant achievements in the field of the latest modern information, communication and computer technologies substantiate and update the need for basic graphic education of the new generation of specialists. Young people must be able to work competently and effectively with the ever-increasing amount of information presented in graphic form and have basic skills for its transformation. Creative activity in preparation for professional activity focused on continuous self-education in the field of graphic information technologies on the basis of research approach is an indicator of culture of a future specialist (Temerbekova, 2019, p. 114).

Scientific bases of the content of graphic culture and methodological approaches to teaching graphic activity in educational systems and complexes are quite fully developed by S.M. Ganeev, S.I. Dembinsky, I.A. Roitman, etc. The technology of formation of graphic culture of students is substantiated and implemented in technical universities (A.V. Kostyukov, M.V. Lagunova, V.P. Molochkov, etc.). The technology of formation of graphic culture of students is substantiated and implemented in technical universities (A.V. Kostyukov, M.V. Lagunova, V.P. Molochkov, etc.). Methodological aspects of the formation of graphic culture of students are presented in mathematics (S.M. Abramovich, L.M. Lopovok, A.A. Lyamina, etc.), drawing (E.I. Korzinova, S.I. Linnik-Botova, N.G. Mikhailov, etc.), informatics (M.V. Apalkova, P.V. Bespalov, N.A. Reznik, etc.). The possibilities of using information technologies in graphic processing and

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transmission of educational information are reflected in the works of L.S. Afanasieva, M.V. Pokrovskaya, V.Y. Rovensky, V.E. Shteinberg and others. The latter show the rational use of information technologies in graphic processing and transmission of educational information. The latter show that the rational use of information technologies contributes to the formation of the graphic culture of students and allows to direct the modern educational process to a qualitatively new level, expanding the possibilities of visual and figurative support of the whole course of studies.

An important part of the general culture of personality is graphic culture, considered from various points of view. N.I. Kalnitskaya defines graphic culture as the highest level of graphic education. According to S.I. Linnik-Botova and V.V. Stepakova, graphic culture is aimed at the formation of the creative potential of the personality in connection with graphic ways of information transformation. S.A. Smirnov characterizes graphic culture as a mechanism of effective use of graphic representations. A.A. Lyamina considers graphic culture from the point of view of the activity approach and emphasizes that the formation of graphic culture of students is based primarily on the mastery of graphic language, development of thinking and creative potential of an individual. V.G. Burov, N.I. Kalnitskaya, S.P. Shultyaev hold a similar position and show that one of the main components of graphic culture of students is spatial thinking. V.P. Molochkov understands graphic culture as a set of skills used in the process of applying information technologies. M.V. Lagunova defines graphic culture as the main element of a person's professional activity. Thus, in the pedagogical lexicon there is a diversity of the concept of "graphic culture". Based on various definitions, we specify the concept of "students' graphic culture" as a set of their personal achievements in the field of mastering and applying graphic methods and ways of transforming information (Solovkina, 2015; Chugunova, 2008).

The revision of the content of graphic education (L.N. Anisimova, V.A. Gerver, V.V. Stepakova, etc.), as well as studies of M.V. Lagunova, etc., allow to consider the process of formation of graphic culture of students from the position of systemic (Y.K. Babansky, etc.) and activity-based (B.G. Ananyev, L.S. Vygotsky, etc.) approaches.

On the basis of the above-mentioned approaches different stages of development of graphic culture of a learner are defined: from elementary graphic training to possible more complete mastery and creative understanding of ways of implementation in learning activities.

These include: basic graphic education, which implies the level of graphic methods and methods of information transformation where students know only the basic minimum acquired at the initial stage of education (I); graphic literacy, which is characterized by the achievement of a certain level of information transformation corresponding to the secondary stage of education (II), with little use of information technology; graphic competence, which reflects the acquisition by students of graphic methods and methods of information acquisition, transformation and application using information technology, creating creative projects in the disciplines (III); graphic culture, which includes an orientation towards continuous self-improvement in the environment of educational activities (IV); graphic competence, competent knowledge of graphic methods and methods of transforming various types of information using information technologies, both in educational and other activities (IV); graphic culture, which includes orientation towards continuous self-improvement in the environment of educational activities (V); graphic competence, competent knowledge of graphic methods and methods of transforming various types of information using information technologies, both in educational and other activities (IV); graphic culture, which includes orientation towards continuous self-improvement in the environment of graphic information technologies, predetermines the restructuring of educational activities based on research and creative approaches (V) (Usova, 2010, p. 12). The inclusion of the individual components of the student's graphic culture is shown in Figure 1.

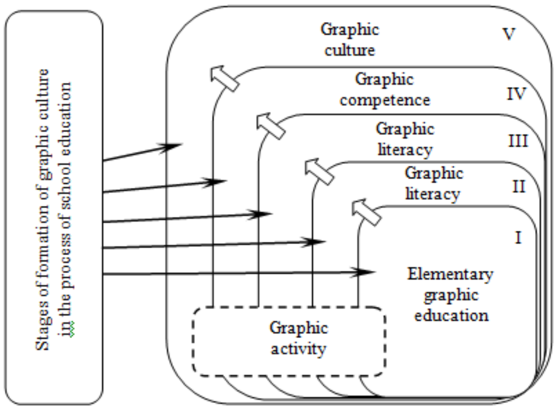


Figure 1: Stages in the formation of graphic culture.

In the aspect of research problems, the work of N.A. Usova deserves attention, where the role of the teacher in the learning process is considered, which requires the quality to process and transmit a large amount of information competently and accurately. In this sense, the most effective means of transmitting pedagogical information are visual means that affect the person through the visual organs. The knowledge of these means and the ability to use them are the components of the graphic culture of a future teacher, the foundations of which can be laid in higher education during the study of various pedagogical courses. At the same time, computer science is traditionally one of the disciplines whose teaching makes the most significant contribution to the formation of the graphic culture of teachers (Usova, 2010).

The problems of graphic culture formation of students are reflected in the study of L.V. Brykova (Brykova, 2011). The author reveals the relevance of the problem, which, in her opinion, is caused by the lack of a methodological system of graphic culture formation of future engineers, which leads to their inability to understand graphic culture as a part of professional culture, as a certain integral quality of personality, providing professional self-improvement and optimization of their abilities in solving professional tasks. The study considers the graphic culture of the engineer as a social phenomenon that cannot be described by a simple sum of components; the structural composition of the components is defined:

- Gnostic - all types and forms of knowledge: from sensations, perceptions and representations to concepts, doctrines and theories, as well as blocks of knowledge: fundamental, technological, economic, aesthetic;

- Technological - the ability to use knowledge in professional activity, to find ways of solving professional tasks;

- Emotional-value - a set of subjective dominants of activity: needs, motives, interests, interests, attitudes, value orientations, personality orientation, ideals, demands, as well as factors motivating activity: analysis of the source of motivation, identification of the reasons for choosing the direction of activity, mechanisms of this process, etc;

- Organizational-projective - ability to analyze and forecast the production process and ways of solving production problems; evaluation of people and the results of their professional activity; mobilization of personal forces for the implementation of professional activity in accordance with the set goals, objectives and given conditions; communication skills, ability to transfer their knowledge and skills to other people.

Here the author also identifies the levels of graphic culture formation in students of technical universities: reproductive - the level of elementary readiness; productive - the level of functional readiness; creative - the level of systemic readiness; cultural-creative - the level of professional readiness. The essence and integrity of the result of education at any level can be understood only on the basis of a clear idea of the structure and hierarchy of educational activity performance, its successively related stages (Brykova, 2011).

The work of V.V. Klyuykov (Klyuyko, 2012) reflects the peculiarities of improvement of professional training of teachers of technology on the basis of computer graphics. The current system of training of future teachers of technology and entrepreneurship does not pay due attention to the teaching of development and application of visual multimedia tools for visualization of teaching materials, contributing to the formation of information and graphic culture.

As a result, future teachers have difficulties in presenting technological information in multimedia form, do not sufficiently take into account the psychological theory of visual information perception and, as a result, do not ensure the formation of information-graphic culture. The paper shows that information-graphic culture, being a holistic social phenomenon, is at the same time a key component of professional and pedagogical culture of future teachers of technology and entrepreneurship. It allows to provide full personal and professional formation and development of future teachers of technology and entrepreneurship in the field of education. Information-graphic culture is considered as an integrative, multi-level, professionally significant personal education, which is manifested in the mastery of information-graphic communication in pedagogical activity with the use of educational multimedia resources.

This idea was further developed in the work of M.A. Kolbas (Sausage, 2013). Modern society is characterized by its ability to adapt to new living conditions in a rapidly changing world. The processes of informatisation and computerization, the emergence of new techniques and technologies in various spheres of human activity have necessitated the development of new approaches to the training of young people for socially useful and productive work, which is the task of technology teachers. In this context, one of the main tasks of the training of technology teachers becomes the need to form information and graphics culture as part of their professional culture, based on computer graphics training.

It should be noted that despite the apparent multidimensionality and breadth of research on the problem of formation of students' graphic culture, many mechanisms of development of this process have not been sufficiently studied and require additional consideration.

2 METHODS

In order to model the process of formation of graphic culture of students using the method of differentiation, the levels of mastery of information culture of students are considered.

The analysis of psychological and pedagogical literature (M.V. Lagunova, B.F. Lomov, V.P. Molochkov, N.F. Chetverukhin, I.S. Yakimanskaya, etc.) allowed to define the criteria of graphic culture formation of students. These are: the use of terminology in the transition from verbal description to graphic objects and vice versa (GT); the use of modern information technology in the construction of graphic images (IT); the use of available knowledge in non-standard situations (NS); the mastery of algorithms for the construction of graphic objects and the creation of generalized algorithms (GS); the development of spatial thinking, spatial imagination and spatial representation (SP); the mastery of techniques for the construction and reading of graphic transformations (RR). The development of each criterion was assessed at three levels (low, medium and high). The results of the formation of graphic culture were also evaluated at three levels: critical (C), acceptable (D), optimal (O).

The elementary knowledge that prevails in the early stages is reinterpreted in the process of the subsequent graphic activity, so that a transition to a qualitatively new level of graphic education takes place. With the help of the graphic activity, the acquired knowledge, skills and abilities contribute to the formation of new skills that facilitate this transition. Later, the synthesis of practical skills and deepened theoretical knowledge leads to the improvement of the newly acquired ways of activity and their transformation into qualitatively more perfect structures of consciousness, which are the basis for their creative and systematic application in practice. This is also confirmed by the data of psychological and pedagogical studies, according to which the process of formation of graphic culture of students is closely connected with the development of special ways of information perception: spatial and visual imaginative thinking, spatial representation, spatial imagination.

In the process of informatisation of education to improve its quality, electronic educational resources have been actively introduced into the educational space in recent years. The state policy in the field of education provides the necessary conditions for a full-fledged quality education, reaching the competitive level for all levels of education, taking into account the interests and abilities of the individual (Myalkina, 2019).

For the formation of graphic culture of students we use electronic educational resources, which allow to develop skills of navigation in various information resources, work with sources, extract from them the necessary knowledge, process the obtained data, as well as have practical skills of work with electronic resources using graphic actions. A.V. Baranov defines the concept of an electronic resource as an educational resource presented in electronic form, containing professional content structured by meaning, recommendations for its use and metadata about it (Baranov, 2019).

In our opinion, an electronic educational resource is a set of various information resources used in the educational process in digital form with the use of graphic sign systems and functions with the help of information and communication technologies. As a means to improve the quality of education, it has a number of characteristics for the formation of graphic culture of students: multimedia, interactivity, universality and accessibility. Among all the existing platforms, the Moodle system is more suitable because it can edit texts with the implemented HTML editor; it has a simple, effective, compatible with different browsers web interface; it has a high degree of communication: it has such tools as forums, chats, wikis, messaging, blogs, etc.; it is dynamic in the use of the course of the training session through a wide range of tools for building the learning process, including not only standard modules, but also additional - text course materials, assignments, tests, etc.). The advantages of electronic educational resources have been identified: students in the learning process can receive not only theoretical material, but also practical tasks, certification and intermediate control; the learning process with the help of electronic resources becomes more dynamic and interesting; there is a possibility to store more information; provide interactivity of learning through multimedia learning tools (Semenova, 2020).

Thus, the use of electronic resources in the formation of graphic culture of students in the educational process allows students to get extended information about the studied area, increases its educational potential. These features provide the student's work at the most convenient pace, which allows to take into account individual characteristics of perception and styles of cognitive activity of students.

The main means of formation of graphic culture of students are computer graphics, pedagogical visuals (drawings, diagrams, etc.), graphic language (an international language of communication based on the system of methods and ways of graphic representation, transmission and storage of various information), materials of interdisciplinary character, contents of educational subjects (graphics, geometry, drawing, etc.) (Solovkina, 2015).

At the preparatory stage it was established that the formation of students' graphic culture implies the necessity of organizational and pedagogical activities for its formation.

The formation of students' graphic culture is a specially organized pedagogical process aimed at the acquisition by students of a set of personal achievements in the field of mastering and applying graphic methods and ways of transforming information. These include: the use of terminology in the process of transition from verbal description to graphical objects and vice versa; the use of modern information technologies in the construction of graphical images; the application of available knowledge in non-standard situations; the use of algorithms for the construction of graphical objects and the compilation of generalized algorithms; the development of spatial thinking, spatial imagination and spatial representation; the use of techniques for the construction and reading of graphical transformations of information.

The structural-functional model, designed to fulfil motivational, educational and developmental functions, was selected from the set of existing models. The constructed model of students' graphic culture formation includes three main components (motivational, theoretical, practical), which are implemented through the introduction of organisational and pedagogical conditions in the educational process to ensure students' graphic culture formation:

- The motivational component performs a motivational function, expresses the orientation to the formation of students' interest in the problem of graphic culture formation and includes needs (personal, social and regional orders of society), goal, objectives and principles aimed at the implementation of the process of students' graphic culture formation.

- The theoretical component fulfils the pedagogical function and expresses the orientation to the acquisition by the students of a set of personal achievements in the field of mastering and applying graphic methods and ways of transformation of information necessary for the formation of graphic culture in the learning process.

- The practical component has a developmental function, which manifests itself in the development of spatial thinking, spatial imagination and spatial representation; work with graphic terminology in the process of transition from verbal description to graphic constructions and vice versa; knowledge of algorithms for constructing drawings and compiling generalized algorithms; mastery of the technique of constructing and reading graphic transformations of information; use of modern information technologies in the construction of graphic images and the use of graphic methods and methods of converting information in a non-standard situation when creating creative projects.

In the process of constructing a model for the formation of graphic culture of students, the following principles were identified as fundamental: visibility, which involves improving the process of perception, understanding and generalization of the studied material by students; consistency of graphic knowledge, which represents a step-by-step process of students acquiring educational graphic information; computerization of training; practical orientation, focused on the practical application of the totality of personal achievements of students in the field of mastering graphic methods and methods of converting information; an individual creative approach, which means satisfying the interests and needs of each student in individual and collective creative activities to create creative projects.

The following organizational and pedagogical conditions have been identified that ensure the formation of graphic culture among students:

- priority of graphic activity in the educational process, which is realized through educational activities, i.e. the process by which a person acquires new knowledge, skills and abilities or changes existing ones; visual activity, i.e. a type of activity aimed at obtaining visually perceived information (diagrams, tables, drawings, etc.), and conceptual and terminological activity, i.e. a type of activity aimed at developing students' conceptual and terminological vocabulary, which indicates a sufficiently high level of mastery of educational material (structural diagrams, reading drawings, etc.);

- orientation towards creative activity, which is understood as an activity aimed at creating and transforming new graphic information and involving self-organization of students (development of creative projects - independently created presentations in any academic discipline with obligatory use of drawings, diagrams, tables, etc.);

- the use of information technologies in the educational process, which includes the implementation of activities on information transformation and application of information technologies; preparation for the formation of graphic culture of students, aimed at professional development in educational programmes, etc.;

- resource support of the process of formation of graphic culture of students, which is focused on practical implementation of the teaching and methodological complex and is aimed at formation of graphic culture of students.

The purpose of the experimental work was to ensure in practice the effectiveness of the process of formation of graphic culture of students and the effectiveness of the organizational and pedagogical conditions identified in the study, which provide the formation of graphic culture of students. The objective was achieved with the help of questionnaire, test and interview methods.

The following tasks were solved: study of the state and development of the problem of formation of graphic culture of students in the conditions of modern educational process; development of pedagogical and methodical complex for teachers and students on application of the approach of formation of graphic culture of students in training; study of the content of teaching materials aimed at transformation of information in the conditions of the proposed methodology; testing of the effectiveness of the proposed model of formation of graphic culture of students. The implementation of the model of graphic culture formation of students included four stages: preparatory, theoretical, practical, analytical.

3 RESULTS

The selection of experimental groups was based on the representativeness of the sample of students. Students of the municipal educational institutions, students of the Gorno-Altai State University, students of the Institute of Education of the Republic of Altai took part in the experiment. The data indicating rather low level of graphic culture formation of the students were obtained at the stage of establishing the experiment: critical level - experimental groups (EC) 55,2 %, control groups (CC) 69,6 %; acceptable level - EC 44,8 %, CC 30,4 %. The tested criteria of graphic culture formation are defined at low and average levels (Fig. 2).

The purpose of the educational experiment was the approval of the constructed model of graphic culture education of students, providing for the increase of the level of graphic culture education.

In order to achieve the set goal the pedagogical-methodical complex (pedagogical-methodical plan, curriculum, test tasks, criterion-diagnostic apparatus, electronic resources, pedagogical-methodical manual "Graphic culture as a condition of learning efficiency", lectures, development of practical, independent and control works) was developed and implemented on an experimental-experimental basis.

The use of information technologies, the use of Microsoft PowerPoint and Microsoft Word programmes in the development of the graphic culture of the students made it possible to involve the children in active, independent work on the transformation of information and the creation of creative projects. Other electronic educational resources were also used, because thanks to them "modern learning can become more dynamic, mobile, accessible and, above all, effective". The use of EER increases students' motivation to learn" (Temerbekova, 2019, p. 253).

Thus, through the formation of graphic culture, students have mastered appropriate graphic methods and ways of information transformation, which are necessary for them to adequately participate in modern educational communication. According to the results of the educational experiment there was a positive dynamics of the level of formation of graphic culture of students (Table 1).

Table 1: Levels of students' graphic culture formation at the formative stage of the experiment.

Groups	N	Levels of graphic culture formation					
		I level, %		II level, %		III level, %	
		к	%	к	%	к	%
CC	79	51	64,5	28	35,5	0	0,0
EC	128	44	34,2	58	45,2	26	20,6

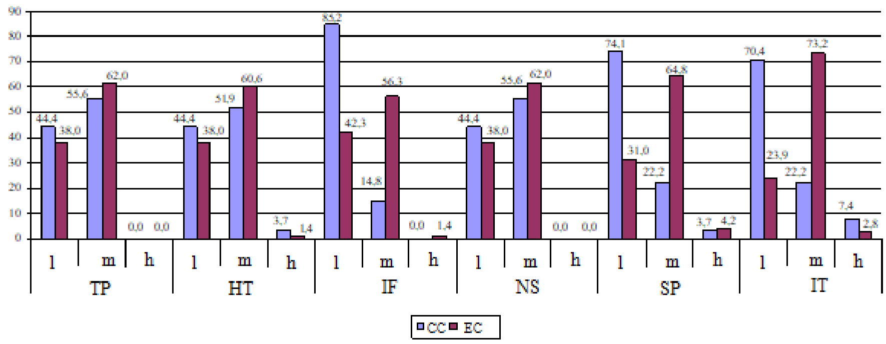
The results of the formation stage of the experiment allowed us to see the growth of the criteria of the formation of the graphic culture of the students (Fig. 3).

The comparative analysis of the data obtained during the formative and formative experiments clearly showed the dynamics of growth of the average value of the level of students' graphic culture formation. Thus, the critical level of students' graphic culture formation in the experimental group decreased by 21%, while in the control group it decreased by 5.1%. The acceptable level slightly increased by 0.4% in the experimental group and by 5.1% in the control group. The optimal level of graphic culture formation of students in the experimental group increased by 20.6%.

Thus, according to the results of comparison of levels of formation of graphic culture of students we can conclude that implementation of organisational and pedagogical influence on the process of formation of graphic culture of students within the framework of our model allows to speak about positive dynamics (Fig. 4).

In the course of the experimental work the hypothesis H0 - the proposed model of formation of graphic culture of students is ineffective was tested. Alternative hypothesis H1 - the proposed model of formation of graphic culture of students is effective. Statistical processing of the research data was carried out using the criterion of Fisher's distribution. Comparing F_{fact} and F_{crit} for the significance level $\alpha = 0.05$, we concluded that $F_{fact} > F_{crit}$ ($2.49 > 1.40$), so at the significance level $\alpha = 0.05$ the null hypothesis H0 is rejected and the alternative hypothesis H1 is accepted. The comparative analysis of absolute frequencies in the samples showed that the process of formation of graphic culture of students in the experimental group is more effective than in the control group. Consequently, the process organized within the framework of the research is effective.

The results of the theoretical analysis and the experimental work allowed us to draw the following conclusions: 1. The study of the state of the problem of formation of graphic culture of students in theory and educational practice shows the necessity of organization of the educational process providing formation of graphic culture of students in the system of general (secondary) education. In the course of the study it was proved that the organization of the process of graphic culture formation is conditioned by regional, scientific and technical, socio-economic needs of modern society and is an important factor in the development of a person of the new millennium. 2. Graphic culture of students is a set of their personal achievements in the field of mastering and applying graphic methods and



TP - mastering the technique of constructing and reading graphic transformations of information; HT - working with terminology in the transition from verbal description to graphic objects and vice versa; IF - mastering algorithms for constructing graphic objects and compiling generalized algorithms; NS - applying existing knowledge in non-standard situations; developing spatial thinking, SP - spatial imagination and representation; IT - mastering modern information technologies in the construction of graphic images.

Figure 2: Criterion indicators of the level of formation of graphic culture of students at the establishment stage of the experiment.

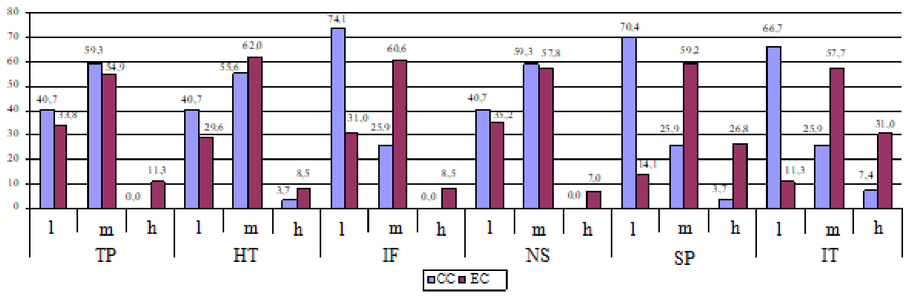


Figure 3: Criteria indicators of the level of formation of graphic culture of students in the formative stage of the experiment.

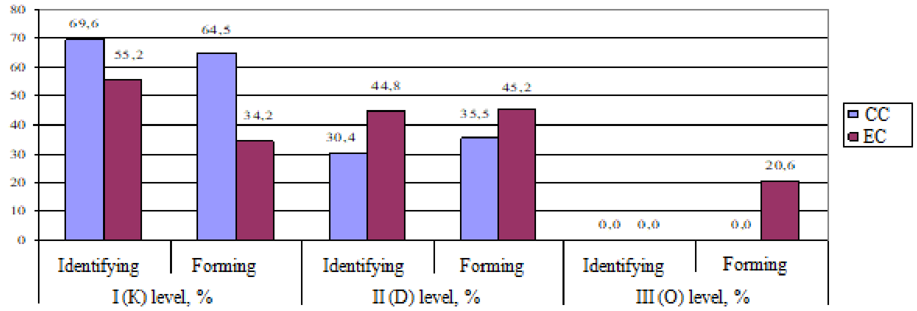


Figure 4: Comparison of the level of students' graphic culture formation in the establishing and forming stages of the experiment.

ways of information transformation. Organizational and pedagogical conditions ensure the formation of graphic culture of students. They include priority of graphic activity in the learning process, orientation to creative activity, use of information technologies in the learning process, teacher training for the formation of graphic culture of students, resource support of the process of formation of graphic culture of students.

3. Developed criterion-diagnostic apparatus for studying the process of formation of graphic culture of students, including: operation with terminology in the process of transition from verbal description to graphic objects and vice versa; mastery of modern information technologies when constructing graphic images; application of existing knowledge in a non-standard situation; knowledge of algorithms for constructing graphic objects and compiling generalized algorithms; development of spatial thinking, spatial imagination and spatial representation; mastery of technique of constructing and reading graphic transformations of information, was used to assess the quality of developing personality. 4. The experimental work carried out in accordance with the purpose and objectives of the study has shown that the implementation of organizational and pedagogical conditions for the formation of students' graphic culture has a positive dynamic.

4 CONCLUSION

The results obtained allow us to formulate the following theses

- Graphic culture is a basic component of the general personality culture, the demand for which is dictated by the modern development of education and society as a whole.

- The conducted research on the development of graphic culture of students is aimed at the prospective development of the educational system in the aspect of the use of digital technologies and various tools and mechanisms in education.

- The use of digital technologies in education can increase the level of graphic culture of students and contribute to the effective training of specialists of higher qualification.

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