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Future Architects' Information Culture Formation While Training

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Abstract

The article outlines the main results of the pedagogical research dedicated to an architect's information culture formation. Based on the analysis of scientific literature and educational experience the structure of an architect's information culture is determined; directions and prospects of ICT use while training architects, as well as features and principles of architects' information culture formation at higher schools, objectives and content of architects' ICT-training are specified; the system of future architects' information culture formation at higher schools is constructed and the pedagogical conditions aimed at its realization are substantiated. An architect's information culture is a knowledge of the information modeling laws, computer-aided design, information message and professional communication rules, ICT-competence possession, as well as awareness of the extent and dynamics of information and resource systems of architecture, design and construction. The results of testing the complex technology of information culture formation are also revealed; the methodology of architects' ICT-training is outlined. The article offers the ways of ensuring the continuity of applied ICT and professionally-oriented knowledge and skills; methods of didactic principles implementation while forming information culture; methods of combining traditional and innovative forms in architects' training. To generate architects' information culture, it is necessary to update traditional methods of education which are based on canons of academic education and introduce modern educational technologies, namely integrated study of computer science, computer modeling and computer-aided design; the use of electronic educational resources; project-based learning; students' research.

Keywords: information culture; future architects; higher schools; information and communication technologies; competence; architectural profile.

INTRODUCTION

The rapid development of information and communication technologies (ICT) in the 21st century is marked by the relentless introduction of ICT tools in all the areas of professional activities, including architecture and design. In this regard, the study of the basics of ICT, information modeling and computer graphics is one of the important areas of training for specialists in the architectural industry. Practice shows that the informatization of their production functions is associated with the formation of information culture of people of "digital generation" among students-architects

Modernization of higher education in Ukraine concerns both updating the content of education and methods of forming knowledge and means of professional activities at higher technical schools, which train future architects. Its current objectives are reflected in the National Strategy for the Development of Education in Ukraine for 2012–2021, and the important issues of architectural education are considered in the International Charter on the Education of Architects sponsored by the International Union of Architects in association with UNESCO (2005). At the same time, the level of architects' training in Ukraine still does not meet international standards and requirements of the information society.

It is now generally accepted that the introduction and application of ICT in vocational training and higher education should be carried out as a system, scientifically grounded, didactically thought-out and organized process (Markauskaitė, 2003; Balendr, et al., 2019).

This requires the development and implementation of electronic educational and method complexes which integrate learning management and control systems, computer versions of courses, electronic educational resources, a database of visual support for the educational process, visualization and modeling systems, virtual laboratory workshops (Bull, Harris, & Drucker, 1992; Ghaleb, 2014; Pegalajar, 2018; Troter, & Ellison, 2001; Balendr, 2018), etc.

In addition, one of the effective means of organizing students' independent activities is the use of cloud services for educational purposes. Companies that have created cloud platforms are deploying a new generation of software based on them, in particular – for educational purposes. The experience of developed countries in the implementation of cloud computing technology in education was analyzed in detail by Hewwit (2008), Sclater (2010), etc. Recommendations for their application at higher schools are provided by a research team of the University of California (Armbrust, et al., 2009). It is noted that educational institutions use cloud services in order to store the main array of data and open electronic educational resources; there is also a transfer to external providers of learning management systems, including Blackboard, Moodle, etc. (Sclater, 2010; Didenko et al., 2020).

The integrated use of ICT in the educational process contributes to the organization of pedagogical interaction in the information and educational environment and ensures an appropriate level of students' professional training in accordance with the standards of higher education and modern requirements of architecture and construction. The analysis of professional activities in this field convinces in productivity of computer-oriented technologies as the tools capable to solve a number of design and compositional problems. As a result, the problem of future architects' information culture formation is actualized, whose training should take into account the possibilities of ICT, which allow increasing the efficiency of education and revealing students' creative potential. The information culture formation is based on the interdependence and unity of the content, technological, diagnostic and corrective functions of the structural components of the education system (Ashworth, & Saxton, 1991; Balendr et al., 2019; Christman, et al., 1997;

Cuban, 2001; Lehtinen, et al., 1998; Komarnytska et al., 2019; Katerynchuk et al., 2021; McCoy, 1996; Reed, 1996).

At the same time, in pedagogical research, unfortunately, not enough attention is paid to the informatization of architectural education, in particular, to the problems of developing the future architects' information culture at higher schools. The study of psychological and pedagogical literature and educational practice convinces that the dominance of empirical ideas in the training of architects does not provide an opportunity to offer an educational system within which the latest pedagogical ideas would be implemented, taking into account the needs of the information society. We believe that: educational design, which is carried out during the training of students-architects, does not meet the requirements of the time; the process of informatization of training of architectural specialists at higher schools is imperfect; and ICT training of students is unfocused and unsystematic. In our opinion, the feasibility of future architects' information culture formation is determined by: the objective need for informatization of their professional training and scientific support for the introduction of ICT in architectural education; insufficient theoretical level of ICT training for students-architects at higher schools; weak link between theory and practice of information culture formation in architectural education; inconsistency of the content, methods, means and technologies of education informatization; the need to improve the methods for information modeling of architectural objects based on three-dimensional computer graphics, as well as visualization of volumetric-spatial images as elements of an architect's information culture.

Theoretical Considerations

The methodological basis of the study is epistemology, phenomenology, semiotics and communicative philosophy; general methodological provisions on the application of systemic, culturological, activities, environmental, and informational approaches; conceptual dominants of the theory of personality; the concept of continuing education; provisions on the unity of cognitive theoretical and practical activities; problem-based learning theory; psychological and pedagogical theories of development and self-development of a personality's professional qualities; the concept of developmental learning, etc. Also, the theoretical foundations of the study include the concept of information society (D. Bell, J. F. Lyotard, Yo. Masuda, A. Toffler, etc.) and the information theory (W. Ashby, L. Brillouin, H. Hacken, C. Shannon, N. Wiener, etc.). Conceptual ideas of informatization of higher architectural education are based on the paradigm of personality-oriented education, the system of lifelong education, the creation of a holistic computer network of education and science based on the means and capabilities of ICT (Adams, & Fuchs, 1986; Fuchs, & Woessmann, 2004; Papert, 1997; Soroka et al., 2019; Shumovetska et al., 2021).

The formation of future architects' information culture requires building training at higher schools of architecture on the basis of the following principles: didactic; vocational education; informatization of education (system application of ICT, unity of semantic and procedural aspects, diagnostics, prognosticity, emotionality, complex computerization of educational process, adaptability to professional activities, intensity of information-technological base); as well as the specific ones we offer (continuity of students' ICT training, complex nature of information and communication technologies, dynamic information modeling, project activities).

Problem of Research

With the development of modern technologies in the scientific community, the concept of "information culture" associated with the functioning of information in society and the formation of an individual's information qualities has emerged, became widespread and relevant. The need to form a specialist's

information culture is recognized by the majority of scientists, paying attention to the different professional orientation and appropriate methods of its formation. The issue of information culture was considered by Michie, & Johnston (1984); Morze (2014); Vamos (1987), et al.

The information culture of people is an integrated indicator of their perfection in various spheres of information activities. The basis of information culture is knowledge of the information environment, the laws of its functioning and development, the ability to navigate in the boundless space of various messages and data, and to use the tools of modern ICT rationally to meet information needs. The level of information culture depends on: personality intelligence, erudition, mental state, worldview and professional level, etc. Regarding professional activities, definitely, each profession requires an appropriate level of information culture. We consider the information culture of a specialist as a component of the future professional one, which is determined by the specifics of the type of activities, the peculiarities of the problems of narrow, special activities facing professionals.

Information culture presupposes developed ICT competence. We believe that this provides effective interaction of a specialist with the information environment: understanding of overarching information laws; skills and abilities to operate with social and professional information; ability to regulate and analyze one's own information-professional field and information behavior at an automated workplace, etc. ICT competence of future architects characterizes the degree of relevant competencies formation, the acquisition and development of which occurs during the entire training at higher schools. The formation of the competencies is carried out consistently and continuously (computer literacy → ICT readiness → ICT competence → information culture), which is facilitated by the continuity of the content of information technology (ICT) subjects, their connection and integration with general professional and professionally oriented subjects. Qualitative professional education is impossible without ICT implementation into the learning process and scientific research (Anderson et al., 2002; Ashworth & Saxton, 1991; Bull, Harris, & Drucker, 1992; Plomp, 2003; Shapiro, & Hughes, 1996).

Since architectural activities requires perfect mastery of various methods, techniques and technologies of information processing and information exchange, we believe that architects need not only an ICT competence to be formed, but a high general level of information management, as well, which is reflected in the developed information culture. An important issue is the purpose of information culture. First of all, it is necessary for the development of professional culture, because the ability to work with information contributes to professional activities, allows making appropriate decisions quickly and correctly, anticipating various situations, and predicting their future actions. Undoubtedly, information culture has orientation (facilitates the acquisition and perception of the necessary data and information), communicative (provides communication and information exchange) and management (allows organizing and regulating information processes and relationships effectively) functions.

In our opinion, an architect's information culture is also a style of thinking, a means of expanding a holistic scientific worldview, a mechanism of interactive communication that meets the needs of the information society. Its formation for future architects is an urgent problem both for Ukraine and for other countries.

Research Focus

In architects' professional activities, ICT has quickly become a leading tool for the performance of official functions. Significant cost, complexity and large volumes of architectural projects lead to numerous studies on the methods to improve the quality and efficiency of design software. CADD (computer-aided design and drafting) of construction objects, virtual modeling and

visualization programs have become widespread. If in man-made design graphic or visual information is expressed in the language of the drawing, with the help of CADD graphic information is stored and operations with it are performed digitally. Undoubtedly, the advantage is the ability of ICT to solve a number of design problems quickly, facilitate architectural design and improve its quality.

Today, ICT is a modern visualization tool, a technical basis of the design process, a virtual modeling tool that can work at the intersection of sciences in architectural design and, probably, other potential opportunities. Computerization methods of architects' design and graphic activities include automation of design, drawing, and solving problems, the data of which are presented in graphical form. We emphasize that while creating a material and spatial environment architects must solve not only three-dimensional, graphic, color, but also information and architectural problems. The efficiency of architectural and construction activities of a modern specialist with the appropriate qualification largely depends on it. The benefits of ICT (Adams, & Fuchs, 1986; Ashworth, & Saxton, 1991; Cuban, 2001; Sheil, 2012) have undoubtedly expanded the capabilities of architects significantly, while increasing the amount of information and knowledge required in the process of architectural design.

The use of ICT contributes to the effective solution of design and compositional tasks and the formation of professional thinking and creative potential. Therefore, the main goal of ICT training of future architects is to provide students with knowledge of computer graphics and to develop skills and abilities to use specialized programs in project activities. Unfortunately, however, the curriculum lacks many important topics; the content, means and methods of studying computer graphics are not considered holistically; and interdisciplinary connections and continuity of ICT training and professional and practical disciplines are insufficient.

Our observations allow us to state that in the field of higher architectural education the potential of modern ICT is not fully used, their introduction into the educational process is spontaneous and often based on intuitive approaches. The possibilities of ICT, which allow solving project-compositional tasks, promoting the formation of professional thinking and revealing the creative potential of a student-architect in accordance with the requirements of the information society, are still little studied and insufficiently used in higher education. We want to note the lack of attention to interdisciplinary connections and continuity of the general professional discipline "Computer Science and Fundamentals of Computer Technology" and professionally oriented disciplines, "Architectural Design" in particular. As a result, the creative possibilities of computer technology are not used, which shifts the emphasis of professional architectural education towards technocracy. We believe that the study and use of ICT can have a significant impact on the formation of professional thinking of students-architects in accordance with the modern needs of the architectural field. It is necessary to use the means of computer modeling to perform research and creative tasks that require a holistic understanding. Theoretical substantiation of the teaching methods for future architect to work in a virtual environment is required, as well as the development of appropriate methods of mastering the design art, the core of which is the architectural composition. The formation of architects' information culture in this regard needs meticulous attention and responsibility, as it lays the foundation for building all the further arsenal of professional competencies necessary for the architect-practitioner.

The purpose of the article is scientific substantiation, development and experimental verification of the system, pedagogical conditions and technologies of future architects' information culture formation at higher schools.

Methodology of Research

The following methods were used in the research process: analysis of modern psychological-pedagogical and methodological provisions to systematize and clarify the theoretical principles of the problem under study; analysis of the professional training results, which made it possible to identify the most productive mechanisms for t information culture formation; observation of students' activities, interviews, questionnaires and self-assessment to identify the level of formation of components of students' information culture; testing and expert evaluation to determine the level of students' ICT training; logical-pedagogical analysis and pedagogical modeling to study the patterns of the educational process development, substantiation of pedagogical conditions and creation of technology for the information culture formation; pedagogical experiment to identify the effectiveness of the proposed innovations; and mathematical and graphical methods of processing results, methods of mathematical statistics to verify their reliability.

General Background for Systematization and Clarification

The experimental work was carried out in five Ukrainian higher schools – Vinnytsia College of Civil Engineering and Architecture, Kyiv National University of Civil Engineering and Architecture, Lviv National Agrarian University, National Forestry University of Ukraine, Lviv Polytechnic National University, Poltava National Technical University – during the 2017–2021 academic years. The main research was focused on the analysis and experimental verification of the effectiveness of the developed system of future architects' information culture formation at higher schools. Namely, the experiment was aimed at fulfilling the following tasks:

1) To identify the features of informatization of higher architectural education;

2) To examine and analyze the readiness of young architects for professional and informational activities;

3) To find out the parameters of students' success, in process of whose professional training ICT will be comprehensively applied in accordance with the developed pedagogical conditions;

4) To determine the degree of information culture influence on the level of the graduates' professional qualification;

5) To check whether there are statistically significant differences in the information culture of the students-architects who study using the authors' technology and in traditional learning.

Sample

The target group of the unique experiment consisted of 25 teachers and 370 students of the 2nd – 4th courses of the «Architecture of buildings and structures» specialty (80 – ascertaining; 40 – preliminary; 250 – formative experiments). A sample of students from higher education institutions was used to test the effectiveness of the developed innovations.

The experiment participant sample was calculated by the formula:

$$n = \frac{t_0^{\,2} \cdot \sigma^2 \cdot N}{t_0^{\,2}\sigma^2 + \varepsilon_{\bar{x}}^{\,2} \cdot N},$$

where: t_0 – critical deviation from the average score (equal to 2.0 with a probability level of .95); σ – standard deviation (found in the previous observation of two groups of 20 students, the variance estimate is equal to 0.58); $\varepsilon_{\bar{x}}$ – marginal error (taken equal to .01); N – total sample (1399 students-architects of higher schools of Ukraine according to the data from the Unified State Electronic Database on Education). In total, the distribution of the representative sample was 250 people. We believe that the experiment seems to be representative and reliable.

Instrument and Procedures

The methodology of the research was developed and grouped under the following dimensions:

1) the level of information culture of the students in the experimental and control groups

was first to determine. The method of complex testing for all the components of information culture without their differentiation was used. For diagnostics, a set of criteria was substantiated, namely – motivational-value, cognitive, activities-technological, emotional-communicative, and reflexive-creative ones, which make it possible to identify the levels of information culture components – low, satisfactory, sufficient, high and creative ones. For the examination, teachers of professionally oriented disciplines of architectural higher schools with more than 10 years of working experience, who are well aware of the production functions of specialists were involved in the examination.

To assess the indicators of motivational and value criteria, students were offered a questionnaire aimed at identifying their personal attitude to the use of information in educational and professional activities. The assessment of the cognitive criterion indicators was carried out on the basis of measuring students' knowledge with the help of test tasks. The indicators of activities-technological criterion were evaluated while carrying out and defending students' educational projects. Emotional-communicative and reflexive-creative criteria were studied through surveys and tests, which included questions about students' stability, independence, cooperation, professional creativity and self-esteem.

2) The next step was to check the quality of architects' ICT training. The knowledge and skills of students in experimental and control groups in the discipline "Fundamentals of computer modeling of architectural objects" were determined and compared. The depth and quality of learning was determined by tests and practical work. Students were offered questionnaires and test tasks aimed at identifying skills and abilities to work with information sources, to analyze information, to use information retrieval systems, to create and design documentation, to analyze and present data. A number of test tasks were developed for automated control: tasks of closed type; compliance tasks; tasks for ranking; situational tasks that provide an opportunity to identify students' ability to apply their theoretical knowledge in practice while solving specific problems.

3) Then the influence of the level of information culture on the professional and project competence of students-architects was revealed, which indicates the productivity of the direction of the educational process on the project professional-information activities of students-architects. For this purpose, the correlation between the level of students' information culture and their qualification in architectural design was calculated in the experimental groups.

4) Finally, the effectiveness of various components of the technology for the future architects' information culture formation was determined. For this purpose, for three years, surveys of scientific and pedagogical workers of architectural profile were conducted regarding the significance of various components of their influence on the formation of students' information culture. The respondents were asked to rank pedagogical technologies according to the degree of importance for the formation of an architect with a developed information culture.

In general, the sound method met all quality criteria. After systematization, generalization and final statistical verification of experimental data, pedagogical conditions were specified and technologies of future architects' information culture formation in the process of professional training were improved, conclusions were formulated. The experts' assessment showed that all the selected procedures were correct and appropriate.

Data Analysis

The probability of changes in the level of information culture and the quality of ICT training of students-architects was checked with a confidence level of 0.95 by t-test. In order to determine the significance of the differences, a null hypothesis about the uniformity of scattering of the data in the experimental and control groups was put forward $H_0: \bar{D}_{KG} = \bar{D}_{EG}$.

An alternative hypothesis claimed that the scattering of data caused by the application of our innovations in the educational process was different: $H_1: \overline{D}_{KG} \neq \overline{D}_{EG}$. Statistical analysis of experimental data was performed using the package Statistica 9. It included: verification of the normality of the distribution (Kolmogorov–Smirnov test (K–S test), Lilliefors test, Shapiro–Wilk test); checking the homogeneity of the samples (Levene's test); testing the hypothesis of mathematical expectations equality (t-test). After studying the similarities / differences between the data of the experimental and control groups, the presence / absence of a relationship between the experimental parameters and a quantitative description of these relationships was established.

To determine the correlation between the students' information culture and their grades for the diploma project, a one-way analysis of variance using the "Data Analysis" add-on in the MS Excel spreadsheet editor was performed. H_0: was formulated: a certain factor (variable) has no significant effect on the obtained result. An alternative hypothesis about the relationship between variables: the level of information culture and professional qualifications of future architects was put forward. The method involved the use of F-test to assess the intragroup and intergroup variance of their professional qualifications. If the observed value of the criterion is less than critical: $F_{emp}<F_{kr}$, the null hypothesis was accepted.

RESULTS OF RESEARCH

Theoretical and methodological studies of architects' information culture

We consider the training of future specialists-architects at higher schools as a dynamic system based on a set of scientific and methodological approaches (systemic, culturological, activities, environmental, informational ones, etc.). On the basis of the analysis of architects' professional activities and their training at higher schools the features of architects' training are revealed, namely: multidimensionality, interdisciplinarity, creative character, propaedeutic stage necessity, orientation on project activities, informatization of educational and professional functions. Improving the quality of architects' education through the introduction of innovations should be carried out simultaneously with the preservation of traditions and identity of their teaching methods.

Specialists' training in higher education is now aimed at educating a professional culture as a form of their consciousness organization, their mastery of knowledge and internalization of certain values with the simultaneous development of general education. This is especially true for architects, whose activities are considered in the "man – environment – culture" system. Professional culture presupposes a formed competence, mastery of task performance strategy, developed professional intuition and creativity (Ball, 2003, pp. 55-56). One of its important aspects is information. According to the concept of A. Ershov and V. Monakhov, the information culture of a person contains, along with computer literacy, knowledge and skills necessary for solving specific information problems. According to I. Zyaziun, the use of ICT in the context of professional training and simultaneous formation of a personality's information culture contributes not only to the development of motivation, professional thinking, educational achievements, but also to the formation of specialists' telecommunication community and implementation of active forms of their constructive interaction (Ziaziun, 2007, pp. 4).

J. Bruner argues that education is not just a technical business of well-managed information processing. In his opinion, "it is a complex pursuit of fitting a culture to the needs of its members and of fitting its members and their ways of knowing to the needs of the culture" (Bruner, 1996, p. 43).

As an element of a person's general culture, information culture is focused on the information support of human activities. It is a

way of thinking, scientific outlook, worldview, and communication skills that meet the needs of the information society (Morze, 2014). An architect's information culture means to master the laws of information modeling, computer-aided design, rules for creating information messages and professional communication, ICT competence, readiness to work with architectural and construction information, as well as awareness of the scale and dynamics of information resource systems in the industry.

The process of future architects' information culture formation in higher education covers worldview-orientation, organizational-communication, information-management, intellectual-developmental, research, as well as general information-communication and professional information-communication components. The latter is a system-forming one, as it allows us to solve the problems of architects' professional information activities comprehensively. The possession of information systems and understanding of information processes provide high productivity and correctness of work of the architect. This component of information culture encourages the introduction of computer-based technologies into education, which contribute to the expansion of design opportunities, artistic value and information potential of architectural design.

Architectural activities involve the use of computer tools for information processing, design automation, engineering calculations and research. The areas of architectural education informatization are based on the analysis of architectural activities, the development of computer-based learning technologies and electronic educational resources and take into account the prognostic prospects of ICT, the latest achievements of pedagogy, psychology and computer science, and the possibilities of educational institutions. Architects and urban planners need to master modern software systems and technologies for creating and processing two-dimensional images Adobe PhotoShop, Adobe Illustrator, CorelDraw, three-dimensional architectural objects ArchiCAD, AutoCAD Architecture, SketchUp, creating and editing three-dimensional graphics and animation 3ds Max, MicroStation design, Artlantis computer visualization programs, as well as V-Ray rendering system, computational automation tools (MS Excel, MathCAD), etc. Architecture and construction now use computer programs to create a building information model – BIM (Kymmell, 2008, p. 4). All components of the BIM are digital information that allows you to create drawings and specifications automatically, to perform project analysis etc.

The appropriate level of all components of information culture must be formed in higher education, in the process of professional training of architects who will be creative in performing information and professional tasks.

In the architects' training ICT is used in three areas: information processing tools (Internet, electronic libraries, information systems, open educational resources); teaching aids (electronic educational resources and educational and methodical complexes); tools of artistic and technical expression (computer equipment and software that allow you to implement the tasks of the architectural and construction industry). An important aspect is the mastery of professionally oriented ICT, including automated methods of spatial information modeling, design, construction, drawing, solving graphical problems, performing calculations, using virtual design environments, etc.

We believe that the best way to prepare future professionals to work with the latest technologies is to introduce them into the educational process. This applies to all the latest ICT tools used in the professional activities of practicing architects

System and pedagogical conditions of future architects' information culture formation in professional training

In order to advance the process of preparation for future architects' information culture formation at higher schools, we have substantiated, developed and experimentally

tested the author's system of their information culture formation. The improvement of the educational system, research of our proposed innovations and study of the consequences of their implementation was carried out from the standpoint of openness, phasing and self-development, taking into account the current provisions of pedagogical science. Diagnosis, analysis, forecasting and optimization of the structure and mechanism of functioning of the system of architectural education in the information and educational environment of the institution were carried out.

The constructed and tested system of architects' information culture formation in the educational process at higher schools allows you to define tasks and components of ICT training and professional information training of students-architects, to reveal their interrelation, to offer updating of the training content by introduction of new subjects (within a variable part), to create information and educational environment, to improve the methods of ICT application in architectural and construction activities, the use of computer-oriented methods and teaching aids and to develop pedagogical technologies of information and graphic modeling and architectural and design activities of students.

The use of our developed system provides individualization of training, reduction of time expenses, minimization of uncreative work of teachers and students, interactivities, feedback and coordination of work of scientific and pedagogical staff at higher schools. All this contributes to the effective application of design and composition tasks, the development of knowledge of computer graphics, skills and abilities to use specialized programs in project activities, which affects the positive dynamics of the formation of components of students' information culture.

The proposed system of future architects' information culture formation reflects the author's vision of productive mechanisms and measures to improve the process of their training taking into account the requirements of informatization of educational and architectural activities, optimizing the content and structure of students' ICT and professional training. For its implementation into the educational process of higher schools the certain pedagogical conditions (a set of opportunities, factors and circumstances of the information and educational environment that ensure the effective functioning and development of professional training) are required. These conditions are as follows:

1. Continuous ICT training of future architects, aimed at the formation of general and professional ICT competencies (work with architectural and construction information; use of computer-aided design systems; creation and application of a computer model of an architectural object; digitization of drawings; visualization of projects, etc.). Improving the ICT training of architects involves a significant expansion of the content and scope of relevant courses ("Computer Science and Fundamentals of Computer Modeling of Architectural Objects", "Computer-aided design systems in Architectural Activities", "Building Information Modeling Technologies").

2. Integrated application of information and communication technologies in the training of architects, which is carried out in three areas: means of searching and processing information (Internet technologies, including cloud services); teaching aids (first of all, electronic educational resources); tools of artistic and technical expression (3D-modeling). ICT allows organizing the information and educational environment of a higher school in such a way that students develop the ability to generate ideas, be creative in professional information activities, and develop their own abilities and capabilities.

3. The use of information modeling while training students-architects in order to acquire theoretical knowledge of computer modeling, skills of modeling and modeling as a powerful method of cognition and the formation of readiness for computer modeling in professional activities, which combines three-dimensional graphic and independent analytical model of the projected structure. The

assimilation of the dynamic means of the BIM by students allows them to master the methodology of architectural activities, to realize the variability of information, to understand the informational essence of an architectural object, and develops the ability to use the potential of ICT in a meaningful way.

4. Informatization of project educational and professional activities of students-architects, aimed at training architects-designers with developed visual artistic and creative qualities, project thinking, ability to work with architectural and construction information and to carry out creative search. Educational projects used in architectural education are practice-oriented, creative, with elements of research. Comprehensive informatization of project activities provides students with a system of design and technical, as well as information and technology, knowledge and skills, professionally important qualities for the implementation of architectural projects and the ability to master the latest technologies in architecture quickly (Lytvyn, 2016, pp. 8-10).

The introduction of sound pedagogical conditions contributes to the actualization and intensification of the learning process at higher schools, the use of powerful opportunities of ICT for the formation and development of future architects' professional thinking in accordance with modern concepts of architectural and construction industry, improving the content, methods and technologies of teaching. At the same time, the information culture of students and, consequently, their readiness for practical professional and information activities, is formed.

Experimental work on future architects' information culture formation

The results of the observational stage of the study showed that 7.2% of students in the final year of higher schools had a creative level of information culture development, 16.8% reached a high level, 24.0% had a sufficient level, 39.2% reached a satisfactory level and 12.8% had a low level. In general, students do not have a clear idea of the nature, content, components, criteria, indicators and levels of information culture; the vast majority of them are not ready to use rational methods of information processing.

Evaluation of future architects' information culture (Fig. 1) showed that the professional information and communication component (14.5% at the creative level and 38.2% at the high level) is the most developed, that determines future architects' professional readiness. The research component of information culture is the least developed (there was no student with a creative level, 56.9% of students with a satisfactory level and 24.5% of students with a low level).

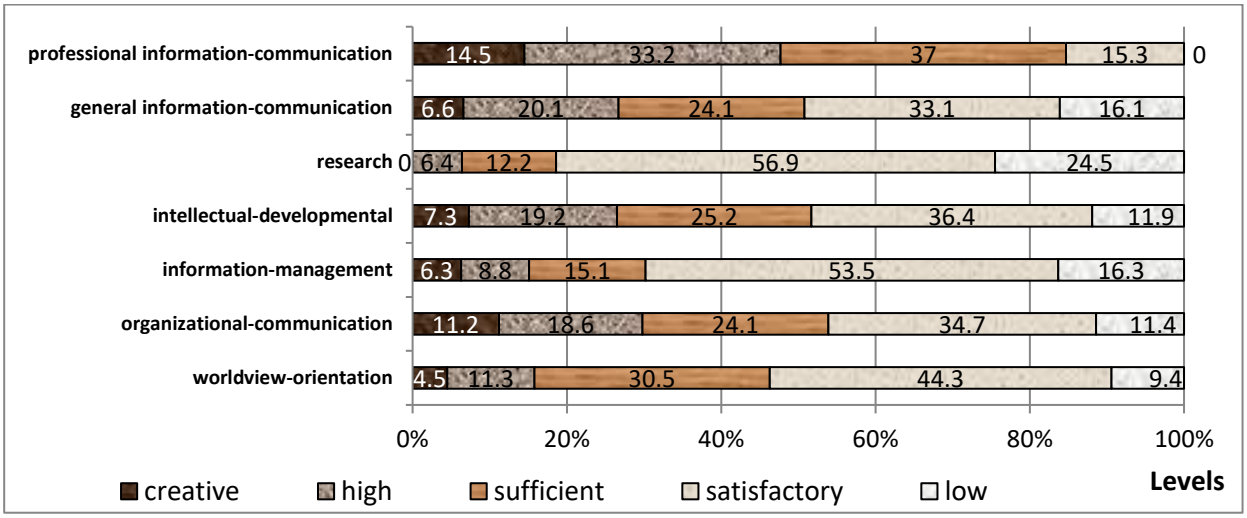

Figure 1. Distribution of students in the experimental group according to the levels of components formation of architects' information culture (ascertaining stage)

It is established that information culture formation in the educational process of higher architectural schools is still not sufficiently purposeful, systematic and personality-oriented; "Fundamentals of Computer Modeling of Architectural Objects" course and other courses of the professional and practical cycle do not properly contribute to the formation of proper information culture among future architects.

While developing and implementing the technology for future architects' information culture formation, we took into account the specific features of pedagogical technologies (conceptuality, controllability, efficiency, reproducibility, algorithmicity, etc.), the peculiarities of architectural education, as well as the impossibility of introducing a separate course for its study. This influenced the choice and application of a set of innovations:

– integrated study of computer science, computer modeling and computer-aided design systems, which allows students to master the methods of computer modeling, the content of architectural and design activities and the concept of BIM, to form a holistic view of the methodology of informatization of professional functions and trends in architecture in information society;

– the use of electronic educational resources, which encourages future architects to work independently with information sources, the use of ICT in information retrieval, self-presentation skills, enhances interest in the development of information culture, and gives a positive experience in the use of its components;

– multi-stage project training: it develops the ability and readiness of higher school graduates for architectural design, which determines the formation of professional competence due to the formation of information culture components;

– research activity: it increases cognitive activity, develops a stable motivation for educational and professional activities and the desire to improve, which leads to the formation and further development of an architect's information culture (Lytvyn, 2016, p. 11).

In order to implement the developed technology, the syllabus of "Informatics and Basics of Computer Modeling of Architectural Objects" course was modernized, "Computer-aided Design Systems in Architectural Activities" and "Building Information Modeling Technologies" courses were introduced. Project training involves a thorough study of "Architectural Design" course, course and diploma projects using the concept of information modeling of the construction object. This contributes to the implementation of interdisciplinarity, integration of knowledge that is relevant in the architectural design and has a positive impact on students' thinking, ICT competence and creativity.

The first component of the forming experiment was the verification of the pedagogical condition – continuous ICT training of future architects. At the same time, the technology of using electronic educational resources was introduced. The results obtained after the introduction of experimental factors (Fig. 2) show that the number of students with a sufficient level of information culture in the experimental group (EG) increased by 20.8%, with a high level – by 11.2% and with a creative one – by 12.8%, and in CG – the number of students with a satisfactory level increased by 11.2%, with a high level – by 2.4% and with a creative one – by 2.4%. In the control group (CG),12.8% of students remained with a low level of information culture and here were only 4% of them in the experimental group.

Calculation of the t-test to compare mathematical expectations of evaluation of the students in the studied groups before the experiment showed t-value = 0,14, and the level of significance > 0,05 (p = 0,864). At the end of the experiment, the value of the t-test exceeds the critical: t-value = -3,64 with a significance

of p = 0,009, which is significantly < 0,05; the sample variances are homogeneous, because p Levene =0,43 > 0,05. That is, the level of information culture of students in the experimental groups differs from the corresponding level of students in the control groups with the required statistical reliability.

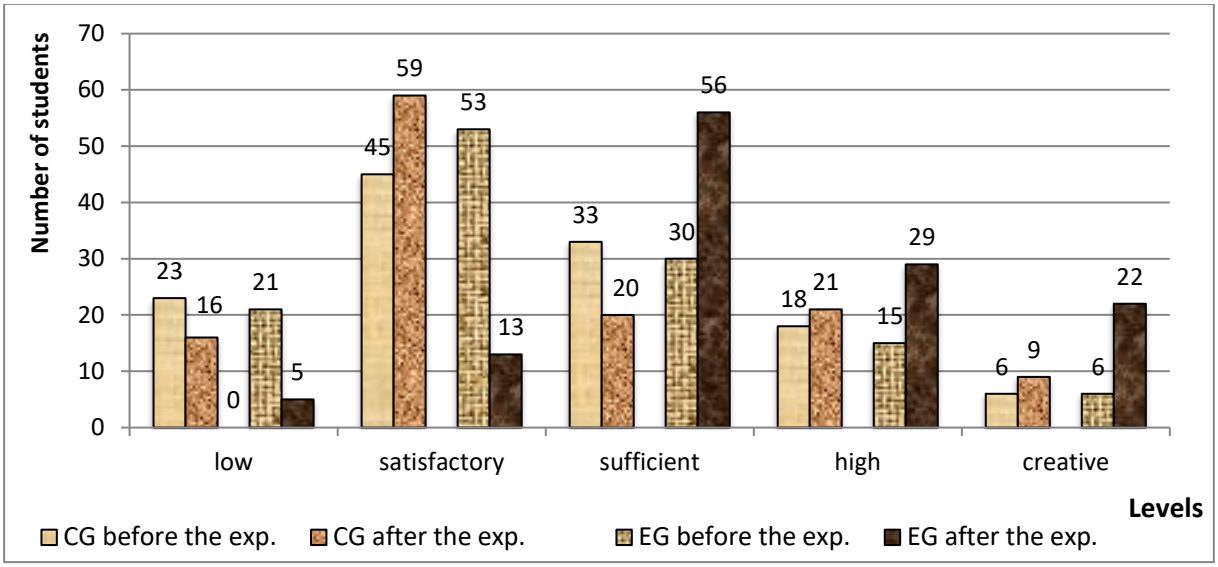

Figure 2. Distribution of students by levels of information culture formation

At the second stage, the pedagogical conditions were tested: the integrated use of information and communication technologies while training architects (in three main areas), as well as the use of information modeling while training students-architects. The technology of integrated study of computer sciences, computer modeling and computer-aided design systems was introduced.

The quality of architects' ICT training was determined by the level of mastering the material of "Fundamentals of Computer Modeling of Architectural Objects" course. In our opinion, this level determines the professional information and communication component of students' information culture and their readiness for professional information activities. The results of the students' academic performance after studying the first and second part of the course are presented in Table 1 and 2.

Table 1. Dynamics of students' academic performance in "Fundamentals of Computer Modeling of Architectural Objects" course (forming stage)

Groups	**Stage of Control**	**Distribution of students by levels of academic performance (score, ECTS)**							
		88 – 100 A		**71 – 87 B, C**		**50 – 70 D, E**		**0 – 49 FX, F**	
		Amt.	**%**	**Amt.**	**%**	**Amt.**	**%**	**Amt.**	**%**
CG	3rd semester	23	18,4	61	48,8	36	28,8	5	4,0
	6th semester	30	24,0	71	56,8	22	17,6	2	1,6
	Increase	7	**5,6**	10	**8,0**	-14	**-11,2**	-3	**-2,4**
EG	3rd semester	24	19,2	58	46,4	38	30,4	5	4,0
	6th semester	44	35,2	73	58,4	8	6,4	–	–
	Increase	20	**16,0**	15	**12,0**	-30	**-24,0**	-5	**-4**

The analysis of the distribution of students by levels of their academic performance (Table 1) shows that the introduction of the author's technology contributes to an increase in the level of information technology knowledge and skills of future architects. In the experimental group, the increase in students with excellent knowledge is 16%, and with good knowledge is 12%. In the control group, these indicators are significantly lower – 5.6% and 8%, respectively.

Table 2. Quality of students' knowledge in control and experimental groups in "Fundamentals of Computer Modeling of Architectural Objects" course

Groups	Stage of Control	Average score	Increase in average score	Quality of knowledge	Increase in quality of knowledge
CG	3rd semester	66,7	9,4	67,2	13,6
	6th semester	76,1		80,0	
EG	3rd semester	67,2	16,6	65,6	28,0
	6th semester	83,8		93,6	

The increase in the average score of students in the experimental groups (on a 100-point scale) is 16.6 points, while in the control groups it is only 9.4 points. According to the indicators of the quality of knowledge, the number of students who studied "excellent" and "good" in the experimental groups increased by 28.0%, and in the control – by 13.6%. Prior to the experiment, the value of the t-test does not exceed the critical (t-value = 0.43; p = 0.668). After the experiment t-value = -6.37; p = 0.004. Thus, the difference between the distributions of the level of academic performance in EG and CG in the studied course is statistically significant, and the effectiveness of integrated use of ICT and the use of information modeling while training students-architects is statistically reliable.

The fourth pedagogical condition – informatization of project educational and professional activity of students-architects – was checked last. Technologies of project activities and students' research activities aimed at development of future architects' professional competence were used.

In order to make sure that the graduates of architectural higher schools can apply the acquired knowledge, skills and abilities of working with professional information in practice, the influence of the information culture level on students-architects' professional and project competence was tested. To check the relationship between these indicators, we grouped the students of the experimental and control groups according to the level of information culture formation and compared these levels with their indicators based on the results of students' diploma papers. That is, we compared how the development of information culture affects the grades that students receive during the final qualifying diploma paper, after which the graduates are got "Bachelor of Architecture" degree. Data from the experimental group of students majoring in "Architecture" are presented in the form of a histogram (Fig. 3).

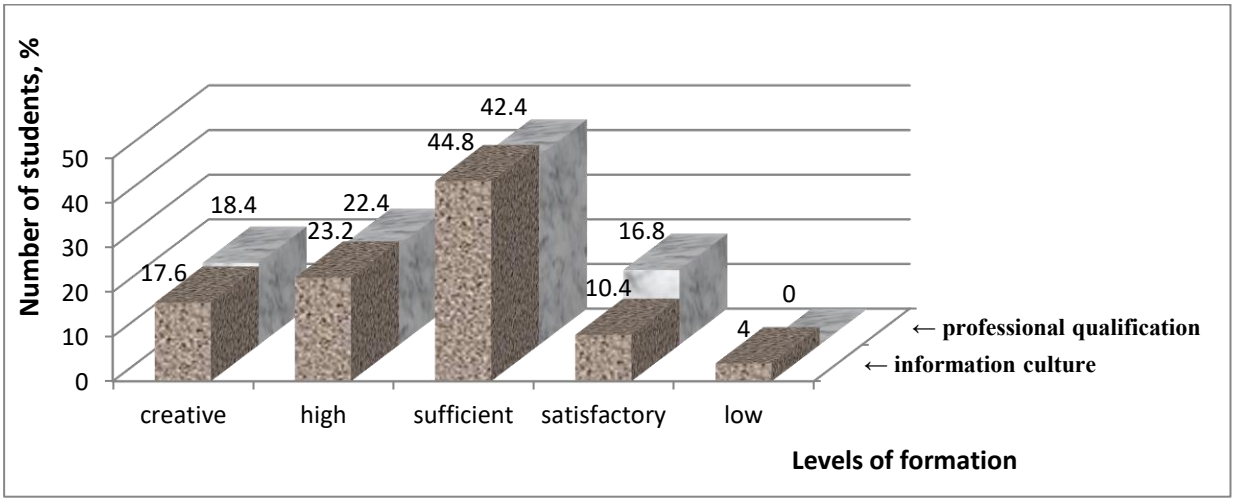

Figure 3. Distribution of graduates of the experimental group by levels of information culture formation and professional qualification

Figure 3 shows that the professional qualification level of graduates generally corresponds to the level their information culture formation. At the same time, one can trace the significant positive impact of professional ICT competence on the design and professional skills of future architects. As the calculated intergroup variance of professional qualification of graduates-architects is much more than intragroup one, the level of information culture statistically coincides with the level of professional qualification of graduates. The revealed stable dependence testifies to the influence of information culture formation on the increase in an architect's professional qualifications. At the same time, according to our data, the increase in the level of future architects' information culture mostly depends on the readiness of teachers to implement ICT into the educational process, as well as the integrated use of ICT while training architects.

At the end of the experiment, we once again determined the formation of future architects' information culture components. The expert assessment was used according to the same methods as at the ascertaining stage of the research.

Figure 4 shows the percentage of architects' information culture components in the experimental group at the end of the research.

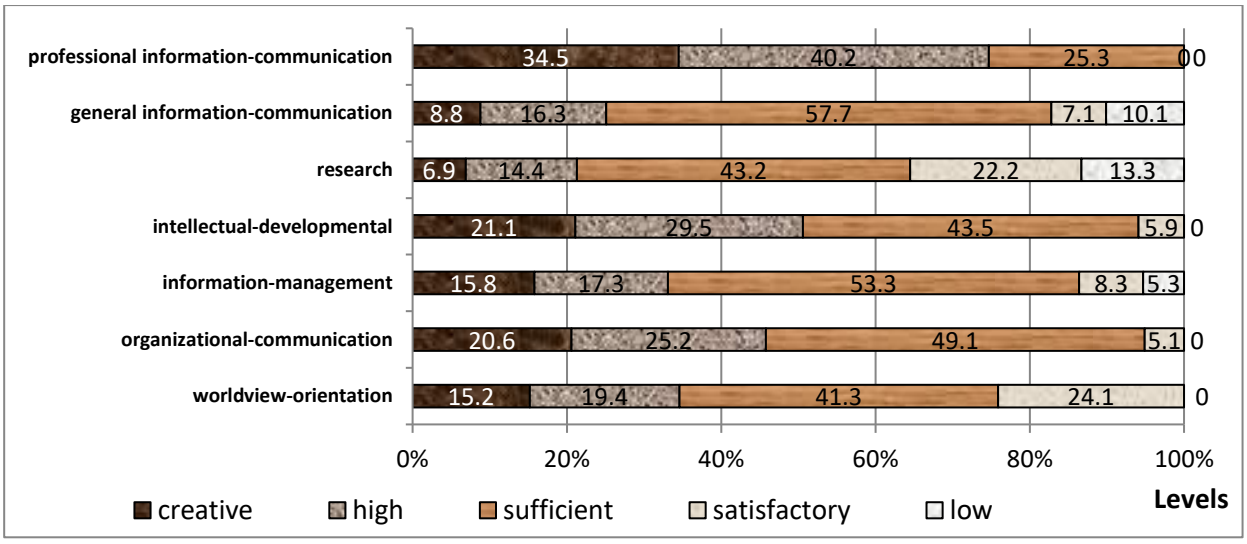

Figure 4. Distribution of students of the experimental group by levels of formation of architects' information culture components (forming stage)

The analysis and comparison of Fig. 4 and Fig. 1 shows that the best developed, as in the ascertaining experiment, is the professional information and communication component of information culture: 34.5% at the creative level (increase in 20%). The research component of information culture also increased (6.9% of students with a creative level, 14.4% with a satisfactory one and 43.2% with a sufficient level). Significant growth due to our activities was shown by the intellectual and developmental component, which determines the creativity of the future architect: 21.1% at the creative level and 29.5% at the high level (growth by 13.8% and 10.3%, respectively). Similar results in the organizational and communication component: 20.6% at the creative level and 25.2% at the high level. At the same time, as we can see from the diagram, the general information and communication component of students-architects remained relatively underdeveloped (8.8% of students with the creative level), as they continue to pay the most attention to professional information and communication. This requires additional measures.

Thus, the results of the forming experiment indicate the effectiveness of the impact of our well-founded pedagogical conditions and pedagogical technologies on the level of future architects' information culture.

Discussion

Based on the research findings this article will contribute to the current discourse on modernization of professional training of future architects in higher education. Extrapolated to the field of education, information technology is an important constituent of the modern paradigm of education. From this point of view, the conceptual ideas of improving higher architectural education consist in the rational use of computer-based teaching aids, as well as specialized software through the integrated use of ICT in the educational process, which will allow teachers to organize pedagogical interaction in information and educational environment and to teach students in accordance with educational standards and modern requirements of the architecture and construction market.

The aim was primarily to analyze the state, features and principles of architects' information culture formation. The results obtained indicate that the analysis of the activities of architectural specialists testifies to the productivity of computer tools and technologies as tools capable of solving a number of design and composition problems. This highlights the problem of architects' information culture formation. Their training involves a combination of educational and methodological, professionally oriented and information and communication aspects, taking into account the possibilities of ICT, which can increase the effectiveness of learning, contribute to the formation and disclosure of creative potential of students. However, despite the significant achievements in this field and the development of the problem in general (Anderson, et al., 2002; Balendr, 2018, 2019; Bull, Harris, & Drucker, 1992; Cuban, 2001; Fuchs, & Woessmann, 2004; Michie, & Johnston, 1984; Lytvyn, et al., 2020; Papert, 1997; Plomp, 2003, et al.), theoretical and methodological principles of informatization in the field of higher architectural education are still little studied and insufficiently used at higher schools. Eventually, the current state of ICT training in the educational process of higher architectural schools is imperfect; in the absence of a specialized course, the formation of a proper information culture of future architects is unfocused and unsystematic.

We would like to emphasize that the majority of scholars and practitioners welcome the introduction of ICT into architectural education. "This is a profoundly liberating and positive condition, and a forward-looking and progressive educational environment can offer

opportunities and rewards that far outweigh the stagnation imposed by certainty» (Sheil, 2014). However, some authors believe that the introduction of ICT is not unequivocally positive, as the transition to computer-aided design impoverishes the emotional sphere and the sphere of associations connected with architectural design and composition modeling.

Future architects must master software systems and technologies for creating and processing two-dimensional images, three-dimensional architectural objects, computational automation tools, etc. The introduction of ICT allows students to solve design and compositional problems effectively and promotes the professional thinking formation and the disclosure of creative potential. However, as it was already mentioned, the curriculum is not perfect; the content, means and methods of studying computer graphics are not considered in their entirety; interdisciplinary links and continuity of ICT training are insufficient.

It is noted that the disciplines of the course of training of architects can be divided into three categories:

• disciplines that can be taught without the use of ICT, for example, architectural drawing

• disciplines in which ICTs play an important role, automating and facilitating the educational process

• disciplines in which the use of ICT can lead to a breakthrough in the quality of teaching and learning.

The third group of academic disciplines is of interest. Significant improvement is due to the application of knowledge formalisation techniques necessary for the successful implementation and use of ICT in the educational process. Thus, comprehension and reflection on the semantic relationships arising in the course of compositional modeling is a means of improving the quality of students' training (Gushchin, & Divakova, 2017).

These findings are consistent with the results of our research. We consider the most promising training in the method of creating a three-dimensional computer model of the object, obtained by transforming the building object into a building information model, as well as the use of virtual design environments that activate students' creativity, form a new structure of professional and information culture of a modern architect.

This study allowed to clarify the following main areas of ICT application while training architects: means of information processing; teaching aids; tools of artistic and technical expression. The most productive is the mastery of professionally oriented ICT, especially digital methods of modeling, design, construction etc. These findings correlate with those reported by Cuban (2001); Pečiuliauskienė, & Barkauskaitė (2007); Troter, & Ellison (2001), who emphasize that educational institutions are increasingly obliged to implement and use ICT. We will add – to form the information and educational environment on the basis of ICT comprehensive implementation in training and learning.

From this point of view, future architects must master programs for creating and editing images, architectural objects, three-dimensional graphics and animation, computer-aided design, computer visualization, rendering, computational automation tools, etc. It is promising to learn the method of creating a three-dimensional computer model obtained by transforming a building object into a building information model (BIM), all components of which are digital information, as well as the use of virtual design environments that stimulate students' creativity and form a new structure of the architect's information culture. We agree with the authors of "E-Learning in Architecture: Professional and Lifelong Learning Prospects", who defined the task of ICT as education of target communities through teamwork on projects due to the ease of communication (Juvancic, Mullins, & Zupancic, 2012).

This study contributed to a deeper understanding of the pedagogical conditions for the future architects' information culture formation while training. As such, these conditions are a set of opportunities, factors and circumstances of the information and

educational environment, i.e: continuous ICT training of future architects; complex application of information and communication technologies while training architects; use of information modeling tools while teaching students-architects; informatization of project educational and professional activities of students-architects. Effective formation of future architects' information culture requires consideration of training principles (didactic ones, professional education and informatization of education), as well as adherence to a number of specific principles: continuity of ICT training of students, complex nature of information and communication technologies, dynamic information modeling, and project professional information activities. All the principles in architectural education operate specifically, which is related to the specific goals of teaching and education.

Another notable finding is that the implementation of a system of future architects' information culture formation in higher education involves the development and implementation of a number of pedagogical technologies aimed at enhancing all stages of professional education and training. The key aspects are the following: integrated study of computer science, computer modeling and computer-aided design systems; use of electronic educational resources; project training technology; research technology (Collis, 1996; Liao, 1998; Lytvyn A., et al., 2020; Reed, 1996; et al.). Thus, there is the modernization of traditional methods of educational design and the involvement of modern productive technologies. The formation of information culture is based on the widespread use of project-based learning methods, increasing the role of independence, organization of students' research and experimental activities, which in turn enhances the purposeful development of both intellectual creativity (variability, hypothetic and improvisation) and emotional and volitional abilities.

To summarize the results of the study, differences in the levels of information culture in the experimental and control groups allow us to conclude that reasonable pedagogical conditions and developed technology are more effective than traditional teaching methods. There is also a correlation between the level of students' information culture and their grades for the diploma project. It follows that the formation of information culture affects the professional development of graduates in "Architecture" specialty.

Simultaneously, there are a number of psychological and pedagogical difficulties. With the help of a survey of scientific and pedagogical workers at higher schools of architecture regarding their readiness to form students' information culture and their application of appropriate technologies in practice, we determined the effectiveness of various components of pedagogical technology of future architects' information culture formation. Teachers and lecturers of "Architectural Design" departments, who participated in the experiment (25 people) indicated the ranks for our proposed pedagogical technologies for future architects' information culture formation, assigning each of them from 1 to 4 points. The results are presented in Table 3.

Table 3. Ranking of pedagogical technologies of information culture formation by effectiveness (forming stage)

№	Technology	Number of votes		Ranking
		points	%	
1.	Integrated study of computer science, computer modeling and computer-aided design systems	69	27,6	II
2.	Use of electronic educational resources	52	20,8	III
3.	Project-based activity	88	35,2	I

4.	Students' research activities	41	16,4	IV

As we can see, teachers and lecturers give a clear advantage to the technology of project activities, in second place there is the integrated study of ICT. At the same time, there is an underestimation of the importance of students' research activities, which allows both future professionals and teachers to be "on the cutting edge" of the latest advances in information exchange and ICT in the field of architecture. To take advantage of all the benefits that improve the quality of the educational process, teachers must know the capabilities and skills of ICT, be able to manage students' activities in the information and educational environment, select and compose teaching materials, methodically competently using electronic educational resources. As a result, interdisciplinarity, integration of knowledge, which is actualized in the architectural design and has a positive effect on thinking, ICT competence and creative potential of students are realized.

According to our research, the increase in the level of information culture of future architects is most influenced by increasing the readiness of teachers to implement ICT in educational activities (Pečiuliauskienė, & Barkauskaitė, 2007; Pegalajar, 2018), as well as the integrated use of ICT while training architects. As a result of purposeful introduction of specialized software into students' project activities, the percentage of ICT use in the process of professional and practical training has increased significantly (≈ by 15%).

CONCLUSIONS

Overall, an architect's information culture means mastering the laws of information modeling, computer-aided design, rules of creating information messages and professional communication, ICT competence, readiness to work with architectural and construction information, as well as awareness of the scale and dynamics of information resource systems in the field of architecture, design and construction. The peculiarity of future architects' information culture formation at higher schools is the gradual nature of the development of its components (worldview-orientation, organizational-communication, information-management, intellectual-developmental, research, general information-communication and professional information-communication), which allow solving the tasks of professional information activities.

Information culture of future architects is formed on the basis of systemic, activities, competence, culturological approaches, as well as taking into account a number of principles, in particular: continuity of students' ICT training, complex nature of information and communication technologies, dynamic information modeling, project professional information activities.

The constructed system of architects' information culture formation in the educational process of higher schools reveals the components of architects' ICT training and professional information training, as well as the mechanisms of their interaction, allows creating information and educational environment, updating the content of education and designing productive pedagogical technologies. Its implementation provides individualization of training, interactivity, and feedback, minimizes the routine work of teaching staff and students, and contributes to the positive dynamics of future architects' information culture formation. The substantiated pedagogical conditions together make it possible to prepare architects for activity in the information environment, to develop their professional thinking and the ability to set and solve creative information-graphic tasks, to form components of professional competence and all the components of information culture. The influence of the development of professional information and communication competence on the dynamics of the qualification level of

specialists in the field of architecture is also confirmed.

The search for new theoretical and methodological solutions to modernize architectural education requires further research on trends and principles of higher schools informatization, theoretical justification of mechanisms for forming the architects' professional culture, development of innovative pedagogical technologies that will positively influence the development of future architects' information culture, as well as the use of foreign experience in creating an information and educational environment at higher schools of architecture, etc.

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