Increase of the Level of Graphic Competence Future Bachelor in Computer Sciences in the Process of Studying 3D modeling

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Abstract. The article deals with the examination of distinct aspects of the application of 3D modeling technologies as the promising trend, which found its application in the process of creation of models for 3D printout, virtual and augmented reality, in the process of development of gameplays, in modeling of objects for educational aims etc. The urgency of the study of the 3D model processing considering the conditions by bachelors of computer sciences, nominated by competitive environment of labour market has been defined. The necessity of improvement of methods of graphical discipline teaching and the actuality of the introduction of the study of 3D modeling technologies in the process of professional training of future bachelors of computer sciences as a promising trend considering the demands of labour market and as the factor raising the level of student motivation to a professional activity in general and the formation level of graphical competence in particular have been grounded. The methodological support of the course has been described, the aim and content of the study of the "Computer Graphics" discipline have been presented. The structure and the content of theoretical and practical parts of the course have been provided, which are oriented to the use of the 3D graphical Autodesk Maya processor. The algorithm has been examined and the stages of creation of organic form objects have been described on the example of modeling of game characters and the algorithm of creation of 3D surroundings on the example of modeling of the game level interior. The certain aspects of informational and communicational support of the "Computer Graphics" course have been examined, within the frames of which the approbation of the developed educational and methodological complex has been performed.

Keywords: future bachelor of computer sciences, computer graphics, 3D modeling, game characters, game surrounding.

1 The introduction

1.1 The problem statement.

The modernity is characterized by extensive computerization in almost all spheres of the social life. Computer graphics gains its advancement in the creation of photo-realistic virtual images, it is used in 3D print technologies, in the modeling of the objects for virtual and augmented reality, in the process of development of gameplay, in the modeling of objects for educational aims, in the performance of complicated graphical projects and many other spheres of people lives. The progressive development of informational and communication technologies has influenced to the advancement of computer games, which became the integral part of everyday lives of majority of people. As it was noted by N. Marenich, the usage of graphics in the quality of processing of visual components of computer games has the rich history, beginning from the traditional pixel graphics and finishing with the leading progressive and prospective technologies of polygonal graphics, capable to create detailed 3D objects [1]. The prerequisite of special requirements to the professional training of future bachelors of computer sciences under the conditions of competitive environment has been the fact that skilled specialists in the sphere of game design have the competitive salaries and often are the most well-paid professionals in the industry of games production. Taking into account the swift growth of demand for highly skilled specialists in the industry of game design and developers of surrounding for virtual and augmented reality [2] the high level of motivation of students to the study of the methods of computer graphics has been observed, in particular 3D modeling, that in its turn raises the role of graphical competence in the modern system of education of future bachelors of computer sciences [3]. Thus, the question of revision of the content and methods of teaching of the number of disciplines stands now, which is aimed at the formation of graphical competence of future bachelor of computer sciences, that is grounded by the researches of needs of contemporary labour market and thus is actual.

1.2 Problem state of the art.

Aesthetic aspects of an art project activity, to which the 3D modeling refers, have been considered in the research of V. Bychkov, E. Iljenkov. The distinct factors of the development of spatial thinking have been studied by such scientists as N. Bondar, I. Nishchak, A. Rajkovskaya, Y. Feshchuk. The formation of graphical knowledge and skills with the help of informational technologies have been grounded by P. Buyanov, M. Ozga, A. Glazunova, R. Gorbatyuk, M Kozyar, V. Kodratova, N. Polishchuk, Y. Ramskyj, I. Semenov, M. Yusupova. The methods of work with 3D modeling software have been highlighted in works of D. Banakh, T. Bordman, G. Greham, M. Dzambruno, J. Johns and others. The issue of 3D modeling also has found its reflection in the research of I. Bratchikov, T. Bulyanitsi, V. Goncharova, T. Koroteeva, T. Nikitina, I. Popova, E. Romanycheva and others. The biggest number of researches in the theory and methods of teaching of 3D modeling of students of

"Computer sciences" specialty have been investigated in foreign publications [4, 5, 6, 7, 8]. In the overwhelming majority of studies of the methods of training of 3D modeling the attention has been paid to engineering graphics by means of CAD-systems for the training of students of technical specialties. But the researches, devoted to the methods of 3D modeling training for the students of IT-specialties, namely the modeling of 3D objects for gameplay or for virtual (VR) or augmented reality (AR), have not been studied sufficiently, thus this issue needs particular attention and thorough scientific research.

The aim of article is the research of effectiveness of introduction of methods of 3D modeling training in the content of "Computer graphics" discipline for the formation of components of graphical competence of future bachelors of computer sciences.

2 The results of research

2.1 The description of educational and methodological complex on "Computer graphics"

The study of the methods of 3D modeling in the process of mastering disciplines, forming the graphical competence, needs the developed spatial thinking, an aesthetic taste, a creative approach and analytic thinking, an exclusive sense of composition, the skills to perceive and produce graphical content, that is caused by the specificity of the discipline. All the qualities of a creative personality mentioned above, as any other ability of a person, are to be and can be developed. Not only perfect knowledge of disciplines of the professional cycle, aimed at the development of skills of programming in various languages influences on the level of professional training of future bachelor of computer sciences, but also the formation of graphical competences. The specialists in the field of computer sciences have to demonstrate the integration of technical, informational and designer skills [9]. At the same time with the mastering of contemporary graphic processors, including the means of 3D modeling, the process of formation of the graphical competence of future bachelors of computer sciences stipulates the acquisition of stable motivation for the usage of 3D processors by students; mastering of skills, ensuring the effectiveness of a professional activity under the conditions of the modern competitive surrounding; the development of creative orientation of the professional activity and critical thinking; the constant work on the increase of professional level; the aspiration for self-education and self-perfection. Modern computer graphical processors, specializing in the 3D modeling, have at their disposal the opportunities of 3D parametric modeling, have big libraries of standardized objects, logical operators and built-up languages of programming. With the aim of formation of graphical competence of future bachelors of computer sciences, the educational and methodological complex has been developed, based on the study of the 3D modeling technology, the approbation of which has been performed in the process of studies of the "Computer graphics" discipline for the students learning the "Computer sciences" speciality. The "Computer graphics" discipline according to the curriculum is studied during the fifth semester. For its study 5 credits ECTS are given,

from which 16 hours are devoted to the lection material, 30 hours are dedicated to lab work and 104 hours to student self-study. The aim of the study of the "Computer graphics" discipline is the acquaintance of students with the peculiarities of modeling, texturing, rendering and animation. For the selection of the content of the course the analysis and the selection of software for 3D modeling have been undertaken [2], according to the results of which for the study of students the 3D graphical Autodesk Maya processor has been chosen, the license for which the Autodesk company has been provided free of charge for three years for the usage at educational institutions. Maya has a powerful toolset for 3D modeling, it fully satisfies the qualifying standards for the development as game characters and also the modeling of game surrounding, that allows to create 3D models of any complexity level [10].

The tasks of study of the "Computer graphics" discipline are the expansion of imagination of students about the purpose and opportunities of the programs of creation of computer graphics and animation; providing for the students the necessary knowledge about 3D modeling; the formation of skills and abilities of students on the creation and application of 3D graphics and animation on the examples of projecting of game characters, surrounding for game levels and the creation of 3D scenes with the usage of the light source; the demonstration of practical significance and orientation of received knowledge and skills in the future professional activity. The obtained knowledge and skills can be used for the further independent study of more complex modes and methods of work in the professional programs of 3D graphics processing, such as 3D Studio Max, ZBrush, Cinema 4D and others. The structure and content of educational methodical complex are represented in the illustration. (see Fig.1). While the development of the methods of study of 3D modeling in the content of the "Computer graphics" discipline with the aim of formation of components of the graphical competence of future bachelors of computer sciences, the training of students in the usage technology of a 3D graphical processor for modeling of game characters, game surrounding and modeling of game levels has been chosen to be the main idea. This allowed to take into account the development of professional competences of future bachelors of computer sciences (the study of the software functional for creation of computer graphics), also the mastering of competences, which are prospective considering the demands of the labour market (to acquire the skills of development of 3D models and surrounding for a gameplay, virtual and augmented realities and so on). The content of educational and methodological complex includes theoretical and practical modules, based on the technology of 3D modeling. Each lecture is accompanied with the demonstration of illustrative material, videos and other materials, which allows to organize systematically the educational material and to form the graphical competence of future bachelors of computer sciences.

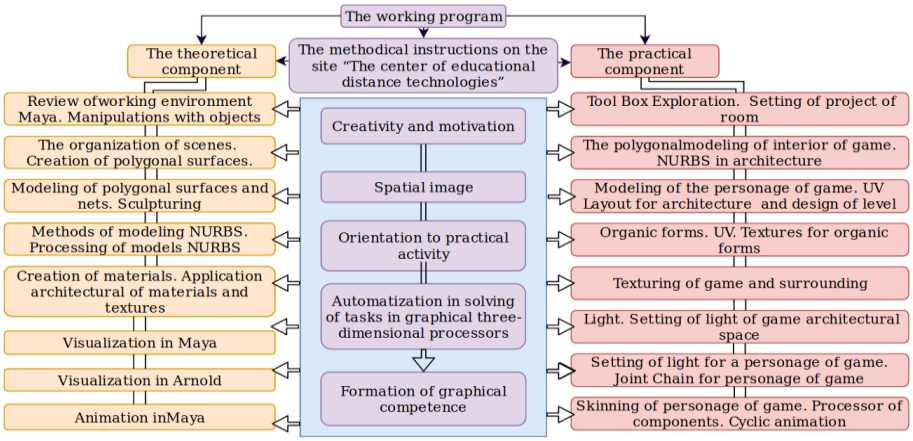

Fig. 1. The structure and the content of educational and methodological complex of the "Computer graphics" discipline for future bachelors of computer sciences.

In the process of usage of obtained knowledge in the practical activity, students form the skills of work with technology of 3D modeling and the motivation for the study of disciplines of the professionally oriented cycle grows. The development of the practical part of the course is built in such a way to accumulate logically the complexity of the developed model, gradually study the model: starting with the development of the concept and projecting all details and images, the creation of structures, studying the texture of model, setting the light and finishing with animation of the model and its rendering. The logical structure of the practical part of the course is represented in the illustration 3, where the sequence of processing of practical lessons is demonstrated by white arrows (see Fig. 2).

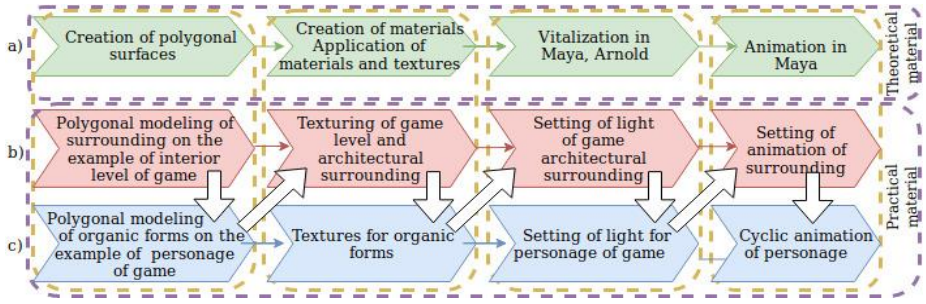

Fig. 2. The theoretical material (a) and the practical material: the algorithms of modeling of 3D objects of an organic form on the example of the characters of the game (b) and space surrounding on the example of the interior of the game level (c)

The result of processing of practical part is two complete 3D models – the model of the character and the example of space organization for a game level. Taking into consideration the necessity of the gradual increase of the complexity of processing of 3D objects, we offer the rotation of practical tasks: performing of every stage of algo-

rithm at first for the modeling of surroundings (as a less resource consuming stage) processing of this very stage of algorithm, but already for modeling of a character (as a more resource consuming one). Such study trajectory of 3D modeling technology is reasonable due to the fact that students in the course of such work during lectures learn the certain stage of modeling theoretically a), and further in the course of practical work they study two branches of modeling of objects simultaneously (personage b) and surrounding c)).

2.2 Description of educational and methodological complex of the "Computer graphics" discipline

The application of information technologies in the education is called to serve the increase of quality, effectiveness and accessibility of training, and the Internet is the unique environment for getting the access to educational materials, gives the potential for teaching and studies, uniting digital technologies and informational resources in the global informational educational surrounding [11]. The important aspect in the training of future bachelors of computer sciences is drawing the process of training to the future professional activity with the use of modern informational communicational technologies and the latest methods and means of ensuring of distant learning nearer. The big volumes of information for students are complicated for mastering in the full mode in the frames of classroomtime, and as consequence the materials should be available for students as while studying in the classroom and also during extracurricular time for their independent study. In the result of unification in the frames of the united curriculum and the educational process of full-time and distance form of studies, the studying process is optimized and the opportunities of participants of the educational process become balanced. Relying on the generic international experience of usage of the distance learning model of the Athabasca University [12], with the aim of support of self study of students and for ensuring of the possibility of the free and comfortable access of students to educational materials, the distance course has been developed. Lectures and practical materials, videos and other useful materials have been located on "The center of educational distant technologies" site of the university, built on the Moodle learning management system. The complex of enumerated elements creates the environment in which students receive the knowledge and transforms their social and professional experience, taking into account various kinds of cooperation. The developed educational and methodological complex is aimed at the formation of the flexible and integral model of training, which can be realized while full-time and distance learning. For the achieving of better results in the process of teaching with the help of distance course we have taken into account the requirements of labour market and specificity of the future professional activity of bachelors of computer sciences. The materials of the educational and methodiological complex are structured on separate educational units (modules) with the outlined educational aim, the introduction, the theoretical part, educational tasks, progress tests and estimation of obtained knowledge. The components of the complex comprise a curriculum, materials for lectures and practical lessons, self-study materials, video series, accompanying every lecture, means of knowledge control in the form of tests, supporting litera-

ture, the electronic register of progress. For the tracking of course element processing, the academic electronic register is provided, which gives the opportunity to record students' progress, reflecting elements, contained in the electronic educational and methodological complex of the discipline and by default rated by the system. The elements, which are rated, include tasks for practical works and tests of theoretical knowledge. The control of practical skills and abilities of students is carried out according to the results of processing of lab works, where students design game surroundings or game characters. The control of theoretical knowledge of students is realized with the help of testing (see Fig. 3).

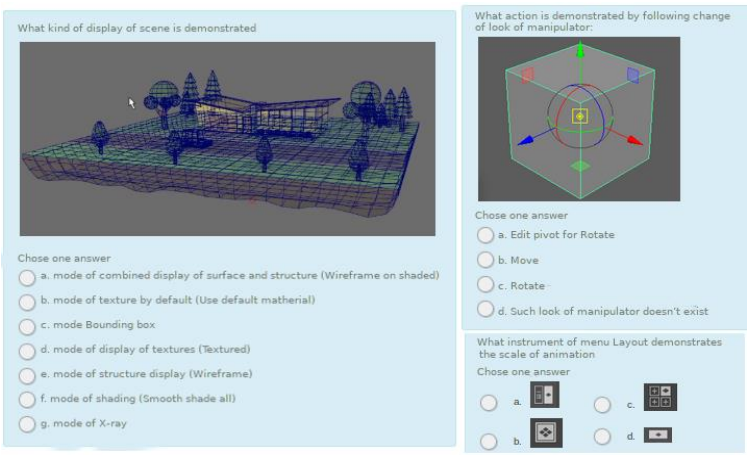

Fig. 3. The example of questions of control

As a means of feedback for realization of communications and qualitative educational support of students the forum has been used, which is the default element for all courses of the Moodle platform and provides all necessary tools for effective communication of students with tutors.

2.3 The results of the pedagogical experiment

Let us examine the results of experimental testing of effectiveness of introduction of methods of 3D modeling learning in the content of the "Computer graphics" discipline and the distance learning course for the understanding of the level of the graphical competence of students. As an experimental group of students third-year students of the "Computer sciences" speciality have been chosen. The pedagogical experiment has been performed in two stages: ascertaining and formative ones. With the aim of research problem revealing, the ascertaining experiment has been conducted, in the course of which the entrance control has been carried out for the study of the initial level of student knowledge on the technology of 3D modeling and the insufficient level of knowledge on 3D modeling technology has been revealed. The results of the entrance control are represented in the form of chart (see Fig.4).

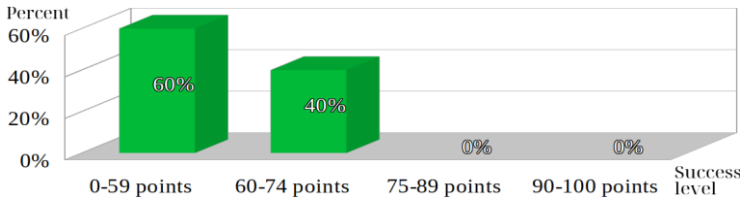

Fig. 4. The results of the entrance control

Thus, the research urgency has been defined and its problem has been formulated, which consists in the necessity of development of methods of 3D modeling teaching, aimed at the formation of spatial thinking, creative approach and aesthetic perception, which are components of the graphical competence of future bachelors of computer sciences. Relying on the conducted research, we have offered an idea that for the increase of the graphical competence level of students, namely the development of spatial thinking, creative approach and aesthetic perception as components of the graphical competence, the use of educational and methodological complex on the "Computer graphics" discipline is necessary. After the conduction of the ascertaining experiment for third-year students the study of educational material has been organized with the use of the developed educational and methodological complex and the distance learning course on the "Computer graphics" discipline. During the formative stage of the experiment the hypothesis was formulated: the introduction of methods of 3D modeling teaching in the content of the "Computer graphics" discipline and the distance learning course will assist the increase of the formation level of graphical competence components of future bachelors of computer sciences, namely the development of spatial thinking and skills of shaping, creative approach and aesthetic perception. For the checking of the effectiveness of introduction of 3D modeling teaching methods in the content of the "Computer graphics" discipline and the distance learning course, the first checkpoint was conducted during the progress control and the second checkpoint was performed at the end of studies of the discipline. Let us build the diagram of the dynamics of students' progress level according to the data of the second checkpoint on the base of obtained data (see Fig. 5).

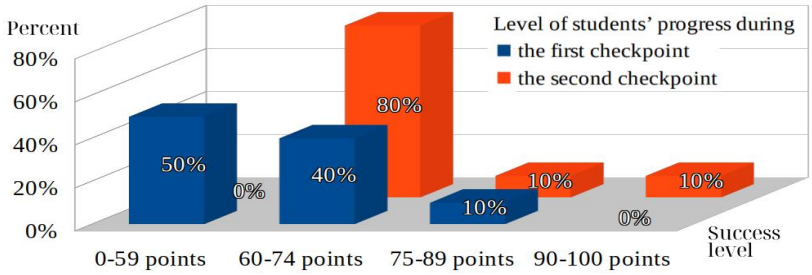

Fig. 5. The dynamics of levels of students' progress points

After analyzing the diagram (see Fig. 4), we can make the conclusion that after conducting the experiment, the general level of progress and the level of formation of

graphical competence components both in the group in the whole and each student individually have increased (see Fig. 6).

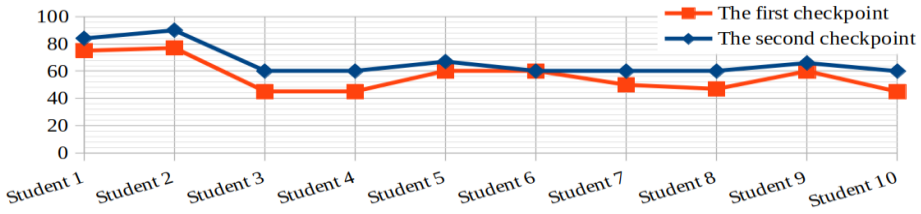

Fig. 6. The comparison of results of the first and second checkpoints of students' knowledge

The comparison of individual progress indicators of students is liable to statistic processing, namely: the number of received points of experimental group during the first and second checkpoints of the experiment. The aim of the research consists in the determination, whether there are enough significant changes and whether it is possible to state that introduction of 3D modeling teaching methods in the content of the "Computer graphics" discipline and the distance learning course have led to the significant change of the level of graphical competence formation. For proving this, we calculate data with methods of mathematical statistics, using Student's t-measure. For the research the null hypothesis have been formulated (H0): the intensity of positive improvements of students' progress while the use of methods of 3D modeling teaching in the content of the "Computer graphics" discipline and the course of distance learning does not exceed the intensity of improvements of student knowledge level while studying offered educational materials without it. We will formulate the alternative hypothesis (H1) in the following way: the intensity of positive improvements of students' progress while using 3D modeling teaching methods in the content of the "Computer graphics" discipline and the distance learning course exceeds the intensity of improvements of students' progress without its usage. According to Student's t-measure H0 can be rejected in favour of H1, if according to the results of the statistical analysis the probability of the accidental appearance of the found difference does not exceed 0,05 or 5%. If the level of credibility is not achieved, then it is impossible to reject null hypothesis. Let us define the value of temp according to formula 1: [13]

$$t=\frac{(M_1-M_2)}{\sqrt{\frac{S_1^2}{N_1}+\frac{S_2^2}{N_2}}} \quad (1)$$

where M1 and M2 – the average value of the first and second points; S1 and S2 – dispersion (standard deviation) for the first and second points respectively; N1 and N2 – the number of grades of the first and second points. Let us define the dispersion according to formula 2 [13]:

$$S^2=\frac{\sum_{i=1}^{n}(X_1-X_2)^2}{N-1} \quad (2)$$

where $(x1 - x2)^2$ – the deviation square of separate values of signs from arithmetic mean; N – the number of signs. The dispersion is the indicator, which shows how the grade distribution curve is diffused regarding the value of its arithmetic value. The calculation of the dispersion of student training level is represented in *Table 1*.

Table 1. The calculation of the dispersion of student training

Checkpoints	Points	Grades	Number of students	Arithmetic mean $x_2 = \frac{\sum_{i=1}^{n}(x)}{N}$	Deviation from arithmetic value x_1-x_2	Deviation squared	Product of the number of grades on deviation squared $n_i (x_1-x_2)^2$	Dispersion $S^2 = \frac{\sum_{i=1}^{n}(X_1 - X_2)^2}{N-1}$
First	0-59	2	5	$\frac{29}{10} = 2,6$	-0,6	0,36	1,80	$\frac{4,4}{9} = 0,4889$
	60-74	3	4		0,4	0,16	0,64	
	75-89	4	1		1,4	1,96	1,96	
	90-100	5	0		2,4	5,76	0,00	
Second	0-59	2	0	$\frac{33}{10} = 3,3$	-1,3	1,69	0,00	$\frac{4,1}{9} = 0,4556$
	60-74	3	8		-0,3	0,09	0,72	
	75-89	4	1		0,7	0,49	0,49	
	90-100	5	1		1,7	2,89	2,89	

After the determination of dispersion, let us calculate $t_{emp.}$ according to formula 1:

$$t_{\text{emp}} = \frac{(2,6-3,3)}{\sqrt{\frac{0,4889}{10}+\frac{0,4556}{10}}} = 2,2778 \quad (3)$$

After the determination of $t_{emp.}$ we compare it with the table value. The table value of t-measure is smaller than calculated ($t_{kr\cdot(0,05)}(2,228) < t_{emp.}(2,2778)$). Let us build the axis of significance. (see Fig. 7).

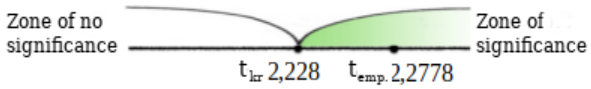

Fig. 7. The axis of significance

In this case, the empiric value gets in the zone of significance. Since t_{kr} (0,05) < temp, this indicates that null hypothesis is rejected, the alternative hypothesis is accepted, namely: the intensity of positive improvements of student progress while using 3D modeling teaching methods in the content of the "Computer graphics discipline" and the distance learning course exceeds the intensity of improvements of stu-

dent progress without its usage for the level of credibility 0,05. Relying on the derived data of the experiment we can affirm that the usage of 3D modeling teaching methods in the content of the "Computer graphics" discipline and the distance learning course has positive influence on the development of spatial thinking and skills of shaping, creative approach and aesthetic perception, which are the components of the graphical competence of students; influences the development of intellectual potential of students, skills of work with 3D processors, improves knowledge required at the labour market; allows to increase the quality of training of future bachelors of computer sciences. The effectiveness of usage of 3D modeling teaching methods in the content of the "Computer graphics" discipline is aimed at the development of 3D models for the gameplay, virtual and augmented realities, in the educational process of training of future bachelors of computer sciences has found its confirmation according to the results of the experimental work.

3 Conclusion

The usage of education materials in the process of professional training of future bachelors of computer sciences is aimed at the development of skills in 3D objects modeling (game characters, objects, surrounding) is the effective method of the increase of motivation and cognitive interest of students. The learning activity, aimed at the development of spatial thinking, creative approach and aesthetic perception allows to bring the training closer to the future professional activity, develop important competences in students: the ability to generate creative solutions, skills to approach critically to solution of set tasks, to base their own conceptions and ideas, to work in a team. The application of educational materials with the developed step-by-step algorithm of modeling of 3D objects in contemporary graphical processors on the example of 3D graphical Autodesk Maya processor makes the training more effective. Taking into account the actuality of the development of 3D models and surroundings not only in the industry of development of computer games, but also in the modeling of virtual and augmented reality, in the movie industry, in the educational process, the usage of 3D modeling teaching methods in the content of the "Computer graphics" discipline will assist the growth of the creative potential and the rise of the professional significant qualities of future bachelors of computer sciences. According to the results of the pedagogical experiment it has been revealed and proved with the help of statistical calculations, that the usage of 3D modeling teaching methods in the content of the "Computer graphics" discipline and the distance learning course in the process of professional training of bachelors of computer sciences is effective, in which the significance of research consists.

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