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Formation of Design Competence of Future Programmers in Training in Three-Dimensional Modeling at the Polytechnic College

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ABSTRACT
Modern technical education poses as a paramount task for professional educational institutions the training and education of a top-class specialist with skills not only in applied computer programs, but also in programming, design, modeling, in the development of project documentation, in the processing of digital data from computer systems. The challenges facing the modern education system are the formation of key competencies demanded by employers, in particular design and engineering. It is this competency that directly affects the formation of a professional in the field of design, engineering and three-dimensional technologies, since students form certain personality qualities in the field of technology and computer science. The essence of the concept "student design and development competence" is established as an integrative quality of a programmer's personality, which determines the level of professionalism in the field of visualization and digital multimedia technologies. The pedagogical conditions for the effective formation of the design competence of future programmers in teaching three-dimensional modeling at the Polytechnic College are determined. This can include the following: the organization of preparing students for participation in the championship "Young Professionals" (WorldSkills Russia), and a specialized assessment system; and application of the design project method; and the development and implementation of a package of training materials of the additional educational program "Three-dimensional modeling". An experiment was conducted and the first results were obtained during the testing of pedagogical conditions for the formation of the design competence of future programmers at the Polytechnic College.
Keywords: *competence, design competence, descriptors, educational course, three-dimensional modeling, WorldSkills*

1. INTRODUCTION

Digital technology today occupies an extensive niche in user demand. All spheres of human life undergo changes in connection with the popularization of the information space. However, despite all the steps that the state takes towards informational modernization of education, we are observing a certain lag behind the main areas of public life [11].

For example, educational institutions have little use of effective digital tools that are already actively used by children and adults in many other areas of activity. It is difficult to surprise a modern teenager with the presence of a 3D printer in college, when at any exhibition in a modern museum or shopping center he can try virtual and augmented reality technologies or use robotics without restriction.

The digital technologies introduced today allow solving key educational problems, but interact poorly with the modern Russian education system based on the use of traditional technologies in the educational process.

Among the tasks necessary to be solved in vocational education through the introduction of digital technologies, we see:

– intellectual and emotional involvement of students in the educational process through the use of various kinds of digital tools to increase the level of visibility of the material studied;
– improving the quality of educational practice of students through the use of three-dimensional modeling technologies and virtual and augmented reality;
– improving inclusive education and distance learning through the installation of modern multimedia equipment;
– the formation and development of professional and key competencies demanded by modern society, such as: design, engineering, engineering - through the introduction of modeling technologies.

In the framework of our study, this technology is used for specialists in a leading field of information technology -

programmers. Graduates of this particular specialty are able to ensure the development of modern technologies and accompany the digitalization process at all stages of the formation of the information society. The development of specialized software, the debugging and support of ready-made software products, the reorganization of technologies and the modernization of various kinds of applications - all this is necessary to maintain the positive dynamics of computerization of education.

2. PEDAGOGICAL CONDITIONS OF FORMATION OF DESIGN AND DESIGN COMPETENCE

2.1. Theoretical aspects of the formation of design competence of students

Modeling is one of the main categories of the theory of knowledge: any scientific research method is essentially based on the idea of modeling, both theoretical (in which various sign, abstract models are used) and experimental (using subject models). We see the application of this technology as a means of creating the design competence of programmers, which will allow them to become more competitive in the labor market and more in demand as high-class specialists.

The design competence of a programmer is an integrative quality of personality of a student-programmer, which determines the level of professionalism in the field of visualization and digital multimedia technologies, which is formed during the training process and manifests itself in readiness for designing and modeling using modern equipment and software, based on special design knowledge design knowledge and skills [7]. From early research, we can say that the formation of design competence directly affects the formation of a professional in the field of design, engineering and three-dimensional technologies, since students form certain personality qualities in the fields of technology, physics, technical and natural sciences, and also computer science.

Since the key aspect of our research is design competence, we have identified the main components of this concept: axiological, cognitive and praxeological. Assessment of the level of formation of the axiological component was carried out according to method A. V. Ermolina and E. P. Ilyin "Motivation and motives". To assess the level of formation of cognitive and praxeological components, we performed a descriptive description of design competence. Let us cite some of them as an example.

The student should know: the principles of geometry for building a 3D model; principles for creating symmetric models and further application of material to them; ways to create a UV scan; rules for the distribution of seams by model; ways to optimize the space on a UV scan through the use of specular reflection and layout of scan elements; the basics of working with texture maps (normal map, defuse, metallic, roughness, ambient occlusion); rules for working with the opacity card to visually display scuffs on clothing or character hair; ways to work with basic and smart materials; basics of rigging a model; work with animation controllers; effective skinning methods of the model; methods for creating simple and inverted kinematics; the main methods of rendering a static and dynamic composition of the model; rules for exporting a model to a game engine; ways to configure the model in the game engine [12].

The student should be able to: use the techniques of sculptural modeling, polygonal modeling, as well as modeling from primitives to create the basic form of the model; use tools and modifiers to create additional model details; UV scan tools for projecting maps on all surfaces of the model; create seams on the surface of the model for further development to the appropriate parts of the UV space; distribute parts of the scan for optimal use of space; export UV coordinates to a texturing program; create physically correct materials and adapt to a given style; create and snap bones to the model to build an ancestor-descendant structure for Direct and Inverse kinematics; set up skinning models and draw the weight of bones on the model; create simple animations to check the movement of an object in the game engine; choose and use the visualization tool (renderer), position the object and lighting, and be able to handle the settings of the visualizer itself; export 3D models and animations to the game engine; choose the optimal game engine and test the model for errors, UV and deformation, etc. [12].

In the field of three-dimensional modeling, professional competencies act as a combination of certain knowledge and methods of activity that a student owns to successfully solve professional problems using computer technology of three-dimensional modeling. Three-dimensional modeling is the most obvious, accurate and complete source of information about the object, with the help of which any graphic information can be generated and formatted, if necessary [7].

2.2. Description of pedagogical conditions for the effective formation of design competence

Following the hypothesis of our study, we assume that the introduction into the educational process of pedagogical conditions for the formation of design competence of future programmers in teaching three-dimensional modeling in a polytechnic college will be effective if:

1. Introduce a specialized assessment system in the educational process of the college based on the criteria-based assessment of the international non-profit movement WorldSkills.

This assessment system is designed in such a way as to accurately and correctly measure the specialist's level of skills and knowledge necessary for a top class professional. The number of aspects should be in the range from 50 to 300 positions in total for all modules. Optimum - from 75 to 250. Each aspect should relate to a specific section of the standard (WSSS) which outlines all the key skills and

competencies of a specialist in a particular field. The weight of one aspect should not exceed 2 points. The total weight of aspects for all modules of the Competition Entry may not exceed 100 points.

Thus, a certain number of aspects makes it possible to examine in detail the process of creating and processing almost any product of an activity. In this case, we are talking about introducing a point-rating system in the educational process, which allows us to solve the problems of inaccuracy in assessment, which are inherent in the usual five-point scale.

2. To organize the preparation of students for participation in the championship "Young Professionals" (Worldskills Russia) in the competence "3D modeling for computer games".

WorldSkills Russia Championships of Professional Skill "Young Professionals" allows imitating the production process with the above indicators as close as possible to the real order of the employer. The competitive task for the championships is developed directly by employers and should necessarily be difficult and practically impossible for a specified period of time, even by a professional. Thus, when participating in such an event, students have the opportunity not only to hone their skills and competencies, but also to compare their performance with other participants from other educational institutions. It is here that an exchange of experience is taken, both between students and directly teachers of professional disciplines.

3. Apply the method of design project in the organization of the educational process of future programmers in teaching three-dimensional modeling.

At the stage of fixing the material, the design project serves as a means to assess the level of preparation of a student against the necessary requirements and criteria. Initially, a project is a sequence of interrelated activities aimed at solving a specific problem and limited in time, place and resources. The effectiveness of design is based on its development at the methodological, theoretical, and empirical levels. Project training can be implemented in the form of research activities, sociocultural design within the educational process of the educational organization, as well as in creative activities. Project activity has an objective pedagogical potential, as it relates to a complex one and, along with the immediate result, it allows one to master universal competencies, form new ideas, meanings and values [8].

4. Develop and implement a package of educational materials of the educational course "Three-dimensional modeling" in the learning process of future programmers.

The developed package of training materials for the course includes: the educational program of the course; educational-methodical manual "Three-dimensional modeling" (in two volumes and has a focus both for students as a supporting educational material, and for teachers in terms of assessing student performance); a set of practical tasks and tasks for independent work; set of video tutorials; base of creative projects; resource base for independent and additional training in the field of three-dimensional modeling.

The process of implementing the additional educational course "Three-dimensional modeling" is designed for 8 months of study, 3 hours a week, with the subsequent delivery of the final graduation work. 8 hours are given for theoretical training in the course, 64 hours for practical training. The main topics of the course are presented in Table 1.

Table 1 Thematic plan of the additional course "3D modeling"

No.	Section name	Number of hours
Total		**72**
1	Concept art	6
2	3D modeling	18
3	UV scan	6
4	Texturing	12
5	Animation	12
6	Render	6
7	Work with the game engine	6
8	Final work	6

The course is studied sequentially from the main ways of working in specialized software to the stage of product modeling in computer programs. At the end of the training, students need to complete the final work, which will consolidate all previously studied topics.

To assess the level of formation of the cognitive component of the concept of "design competence", methods were used to identify knowledge in the field of three-dimensional modeling technologies and robotics. To assess the level of formation of the praxiological component, the final practical work is used according to the standards of the WorldSkills Russia demonstration exam in the competency "3D modeling for computer games" [12].

3. EXPERIMENTAL WORK

3.1. Experiment stages

To track the level of development of design competence, we used theoretical methods (generalization and systematization of scientific provisions on the topic of research); empirical - observational (direct and indirect observation), diagnostic (questioning, testing) prognostic (method of expert assessments), experimental (constructing and forming experiment), systematic (methods of measuring the mathematical processing of experimental data obtained during the study, their systematic and qualitative analysis). Testing the results of a study on the design competence of students-programmers was carried out on the basis of the Autonomous Institution of Professional Education of the Khanty-Mansiysk Autonomous Okrug - Ugra "Surgut Polytechnic College"

(Surgut). In total, three academic groups (72 students) aged 17 to 20 years from college took part in the course, namely:
– 24 students (specialty 09.02.03 Programming in computer systems and complexes, the second course of study);
– 22 students (specialty 09.02.03 Programming in computer systems and complexes, the third course of study);
– 26 students (profession 09.01.03 Master in digital information processing, the second year of study).
The age of the students complies with the standards of the international movement of working professions WorldSkills International and the Russian system of world championships of professional skill WorldSkills Russia, as well as the industry championship WorldSkills in the field of information technology Digital Skills. Students who have completed additional education courses can take part in a series of championships such as:
– 3D modeling of computer games;
– Development of virtual and augmented reality;
– Prototyping;
– Digital Fashion Designer (FutureSkills) [6].
The study was carried out in the following stages:

1. The ascertaining stage (September 2018). At this stage, campaign work was carried out, a group was set up to study the additional educational program "Three-Dimensional Modeling", as well as specification of the main theoretical provisions of design competence and identification of the initial level of competency formation.
Based on the above diagnostic methods, three levels of formation of students' professional competencies were identified:
– high level (36 - 50 points) - characterized by the presence of strong motivation for professional activity, a high level of knowledge of theoretical and practical material;
– average level (21 - 35 points) - characterized by knowledge of the basics of work in the field of three-dimensional modeling and robotics at an average level; able to predict the result of activities, however, rarely makes decisions in favor of optimizing activities;
– low level (0 - 20 points) - is characterized by a weak level of knowledge on working with modeling software and robotics equipment; lack of motivation in further professional development.
Table 2 shows the level of development of design competence at the ascertaining stage.

Table 2 The level of development of design competence at a ascertaining stage

Level	Number of students (pers.)	Number of students (%)
High level	5	6.9
Average level	21	29.2
Low level	46	63.9
Total	**72**	100

2. The formative stage (October 2018 to May 2019). Organization of an additional educational process, tracking the results of a group by the level of development of design competence, testing the research hypothesis.
3. The control stage (June 2019). Summing up student learning, measuring the level of development of design competence after training on the course; analysis and drawing conclusions as a result of work.
At the end of the course, repeated testing and questionnaires were carried out, as well as completed projects of students were taken into account. Thus, as a result of the analysis, the following level of students' design competence formation was revealed, which is described in Table 3.

Table 3 The level of development of design competence at the control stage

Level	Number of students (pers.)	Number of students (%)
High level	42	58.3
Average level	27	37.5
Low level	3	4.2
Total	**72**	100

3.2. The discussion of the results

Thus, we can conclude that the proposed pedagogical conditions for the formation of the design competence of future programmers in teaching three-dimensional modeling at the Polytechnic College have proved their effectiveness, because:
– the percentage of students with a low score decreased by 59.7%;
– the number of students with a high score increased to 42 out of 72 - this is 58.3%;

– On average, 69 people mastered the program and were able to achieve the required level of development of design competence - this is 95.8% of students.

Also, it should be noted that five students excelled in preparing for the WorldSkills standards championship and took part in the regional championship "Young Professionals 2018" of the Khanty-Mansiysk Autonomous Okrug - Ugra in Surgut, where three participants took all the places on the podium. One of the winners of this championship from the group by profession "Master in Digital Information Processing" took first place in the Final of the national champion "Young Professionals" according to WorldSkills Russia standards in Kazan on May 24, 2019.

4. CONCLUSION

The results obtained during the first testing of pedagogical conditions, although they have proved their effectiveness, but require refinement in the content. When conducting a repeated experiment, we plan to avoid the following difficulties identified at the stages of work with:

– finalization of an additional educational program to facilitate the assimilation of material by students and increase the level of motivation for learning;

– development of additional literature and video material to accompany the training course and prepare for championships according to WorldSkills standards;

– optimization of criteria-based assessment of student work for a more convenient form of reporting and analysis of results.

REFERENCES

[1] Hristov, Pavel & Petkov, Emiliyan. (2019). Study of 3D Technologies for Web.

[2] Serrano, Noemi & Pocinho, Margarida & Farnicka, Marzanna & Garcês, Soraia. (2017). 3D TECHNOLOGIES AND CREATIVITY IN CHILDHOOD EDUCATION. 8816-8823. 10.21125/edulearn.2017.0656.

[3] Strutynska, Oksana. (2019). THE USE OF ROBOTICS AND 3D TECHNOLOGIES IN THE STEM EDUCATION DEVELOPMENT. 96-109. 10.28925/2414-0325.2019.7.10.

[4] Federal'nyj gosudarstvennyj obrazovatel'nyj standart srednego professional'nogo obrazovaniya po special'nosti 09.02.03 Programmirovanie v komp'yuternyh sistemah [Elektronnyj resurs] / Rezhim dostupa: http://disclosure.ggpi.org/sveden/files/standart_09.02.03.pdf. – Zagl. s ek.

[5] Aver'yanova, N.V. Osobennosti psihofiziologicheskogo razvitiya studentov v processe obucheniya na fakul'tetah estestvennonauchnogo i gumanitarnogo profilya / N.V. Aver'yanova // Vestnik KemGU. 2014. №1 (57).

[6] Atlas professij [Elektronnyj resurs] // Rezhim dostupa: httr://atlas100.ru/satalog/obrazovanie. – Zagl. s ek.

[7] Buerov, A.S., Bezymyannaya, A.D. Formirovanie professional'nyh kompetencij studentov vysshej shkoly v usloviyah realizacii obrazovatel'nogo kursa «robototekhnika i trekhmernoe modelirovanie» [Tekst] / A.S. Buerov, A.D. Bezymyannaya // Azimut nauchnyh issledovanij: pedagogika i psihologiya. 2018. T. 7. № 4 (25). S. 49-51.

[8] Varlakova YU.R. Formirovanie gotovnosti k proektnoj deyatel'nosti budushchih pedagogov v usloviyah vvedeniya FGOS 3++ v VUZe. V sbornike: Luchshaya nauchnaya stat'ya 2018 Sbornik statej XIX Mezhdunarodnogo nauchno-issledovatel'skogo konkursa. 2018: 41-43.

[9] Nasyrova, E.F., Danilov, A.A. Informacionno-metodicheskaya kompetenciya pedagoga [Tekst] / E.F. Nasyrova, A.A. Danilov //Azimut nauchnyh issledovanij: pedagogika i psihologiya. 2019. T. 8. № 1 (26). S. 94-97.

[10] Nasyrova E.F. Additional education in the self-development of teenage / A.V. Demchuk, M.R. Arpent'eva // Advances in Social Science, Education and Humanities Research, volume 331//1st International Scientific Practical Conference «The Individual and Society in the Modern Geopolitical Environment» (ISMGE 2019). S.493-500 (Web of Science).

[11] Odarich I.N. Metodologicheskie podhody k proektirovaniyu processa formirovaniya professional'nyh kompetencij budushchih bakalavrov stroitel'nogo profilya // Baltijskij gumanitarnyj zhurnal. 2016. T. 5. № 1 (14). S. 132-135

[12] Tekhnicheskoe opisanie kompetencii «3D modelirovanie dlya komp'yuternyh igr» [Elektronnyj resurs] / Rezhim dostupa: https://worldskills.moscow/kompetencii/#comp_list – zagl. s ek.