EasyChair Preprint

№ 8606

Peculiarities of the of Engineering Disciplines Teaching Process Organization Using Three-Dimensional Computer Modeling Methods

Yelistratov Viacheslav, Pavlenko Olexandr, Kharkov Olexandr, Chernenko Serhii, Chernysh Andrii and Puzyr Ruslan

August 5, 2022

Peculiarities of the of engineering disciplines teaching process organization using three-dimensional computer modeling methods

Viacheslav Yelistratov
Department of automobiles and tractors
Kremenchuk Mykhailo Ostrohradskyi National University
Kremenchuk, Ukraine
0000-0001-7931-7761

Olexandr Pavlenko
Department of automobiles and tractors
Kremenchuk Mykhailo Ostrohradskyi National University
Kremenchuk, Ukraine
0000-0001-8277-340X

Olexandr Kharkov
Department of automobiles and tractors
Kremenchuk Mykhailo Ostrohradskyi National University
Kremenchuk, Ukraine
0000-0003-2561-4837

Serhii Chernenko
Department of automobiles and tractors
Kremenchuk Mykhailo Ostrohradskyi National University
Kremenchuk, Ukraine
0000-0002-7670-5168

Andrii Chernysh
Department of automobiles and tractors
Kremenchuk Mykhailo Ostrohradskyi National University
Kremenchuk, Ukraine
0000-0002-9711-827X

Ruslan Puzyr
Motor Cars and Tractors Department
Kremenchuk Mykhailo Ostrohradskiy National University
Kremenchuk, Ukraine
0000-0001-9791-9002

Abstract – The article examines the technology of teaching organization and methodological features of the development and implementation of educational programs in the field of information computer technologies. 3D technologies using potential investigated in order to improve the quality of professional training of students was investigated and intensification of the educational process in a higher educational institution by increasing the interest of participants in the educational process to study and more active an educational disciplines sections mastering.

Keywords – engineering, digital technology, electrical engineering, computer graphics, 3D modeling, education

I. INTRODUCTION

One of the necessary conditions for ensuring modern state competitiveness on the world market is the availability of well-prepared specialists which have all the necessary skills for independent creative and engineering activities in various industries and economy [1].

Information technologies of digital 3D-modeling and production are the current areas of modern industry and the fastest growing economy.

There is a great demand for specialists who have a high level of 3D-modeling technologies in various industries.

The rapid development and availability of production tools such as industrial 3D-printers, laser systems for cutting and processing a variety of materials, numerical control machines, as well as computer programs for 3D-modeling indicate the need to train professional personnel in this direction.

Today's requirements for modern education quality improving in higher educational institutions encourage the universities teaching teams to search for new forms, methods and means for improving their educational activities. One of these, the most effective means, is training in computer modeling, which comprehensively combines theoretical and practical methods of training specialists [2].

One of the main tasks of teaching disciplines related to the study of information technology is the formation of systemic thinking among students in the field of computer technology [3]. Integration of education as a whole takes place, interdisciplinary relations are implemented, the interest of students in obtaining and mastering new professional competencies increases during obtaining theoretical knowledge and practical modeling skills process.

Computer modeling is also one of the most powerful means of forming information and production culture in today's youth. Stimulates the development of systemic thinking, which is necessary for the modern design software effective using.

A prerequisite for mastering computer modeling skills is practical work with virtual three-dimensional models, during which students studying this discipline are familiarized with the methods of their creation, obtaining ideas about the model parameters, the ratio of the obtained model and the real prototype or future product, the essence of physical processes that ensure the operability of the final product. At the same time, the skills of research work, planning of research, competent interpretation of the results of the work performed are formed [4].

Recently, a large number of powerful computer software tools for modeling, visualization and research of three-dimensional objects have appeared.

3D graphics make it possible to create volumetric models of objects of different geometric shapes, even very complex, imitating even the material from which they will be made.

Information that is clearly presented in visual form is perceived much more easily than that given in any other way, while complex information structures and relationships are recognized in a shorter period of time. Such information is absorbed in a larger volume and with less distortion compared to other, traditional, teaching methods used in the educational process.

The general essence of the 3D-modeling is that the designer develops a geometric model in its natural visual form [5 – 7]. Construction of the object's drawing usually is carried out at the final stage, to a large extent in the automated mode provided by graphic editors of modern computer software.

II. Methods of Research

During the educational process organization in a higher educational institution, information computer technologies are widely used, which seriously affect the organization of this process. This should be done because the interaction nature between the student and the teacher changes significantly, in which a considerable part of the pedagogical functions rely on the electronic computers using.

The study of three-dimensional computer modeling at a university can be organized for students of various training profiles: mechanical, electrical or other specialties, and not necessarily technical areas.

To study the studying process organization and mastering three-dimensional computer modeling by students of a higher educational institution, the following research methods were used:

– actual literary sources analysis on the topic under study;

– conversations with teachers and students involved in the relevant educational process;

– joint use of computer supports to eliminate difficulties encountered in mastering issues related to the computer discipline studying;

– conducting theoretical and practical training on three-dimensional modeling using components of the computer-aided design system (CAD, CAM, CAE, CALS);

– observation of the student's educational activities during their development of three-dimensional computer modeling and methods of studying the obtained models.

III. Experimental research

Since the end of the last century, due to the economy growing needs in information disciplines quality education, various computer courses have been emerging and starting to develop rapidly. At that time, there were discussions in the education system between supporters of the teaching computer disciplines theoretical concept and supporters of the so-called "user approach" [8].

According to the former, programming is the second literacy of the population, algorithmic and programming skills are fundamental components of human activity, and their formation is the main goal of training specialists.

Supporters of the second approach proposed to focus on the practical user skills development in the application of applied computer programs, such as office applications, graphic and other editors, based on the employers request for specific skills and skills.

Combining both of these areas within one or a small number of academic disciplines is almost impossible. The amount of study time allocated to them cannot, in principle, accommodate training in all areas of computer technology, even in certain specialties.

The training course in information computer disciplines should be built on a gradually complicated sequence educational tasks solving basis. This approach simultaneously provides the education programs content flexible adjustment for a specific contingent undergoing training and provides the possibility to formalizing the content of this education programs.

Consistent solution of similar practical and theoretical problems is a prerequisite for the student's intellectual and professional abilities development. A Similar training system creation is an important component of an educational and professional programs development for the training of specialists, which ensures its conceptual integrity and wider adaptive capabilities.

The educational program of professional training should consist of three specialist training levels: initial, basic and advanced. Each of these levels should be distinguished by a degree of specialization and a building educational tasks system that are characteristic only for it.

Practical experience, which was obtained by the teachers of the Department of Cars and Tractors during the teaching such disciplines as "3-dimensional technologies in car design," "Automated Engineering Analysis Systems" at various educational degrees gives reason to consider it appropriate to divide the specialist's education process in engineering into several levels. Consistent these levels acquisition should take place in different courses and different educational degrees (Bachelor, Master).

The initial level, which should be implemented in the first or two first higher education institution study courses, should allow for general orientation in the field of computer technology. That is, at the initial level there should be no specialization in educational training at all. Students should acquire relevant knowledge and skills that would allow them to freely navigate in any field of information technology.

The basic professional training level should ensure the ordering experience and knowledge gained during the first stage of training, and formation a systemic type of thinking in a certain subject area. Created systemic thinking will allow students to transfer the solving educational problems processes to a higher and independent awareness and arbitrariness level.

The development of this type of thinking with orientation to the educational activity subject area should be connected with the development of project competencies. The training task chain complexity at the level of basic training should be directed towards the structure of the projected object, which, in turn, will complicate the relevant technological operations.

Successful development of the professional first two levels training will allow moving to mastering specialized specialization. This will enable the further professional orientation implementation, which is inextricably connected with the development and technological design solutions effective implementation. Mastering the professional specialization will allow students, and subsequently specialists, to organize the process of finding the necessary technological solution in education and then production field.

According to the gradually complicating tasks concept at the end of the development of the training last level, future specialists must solve training tasks that differ little from the real production tasks.

To implement the described future specialists professional training strategy in mechanical or electrical engineering, the course of information and computer training must contain the following types of disciplines: fundamental, which should represent the drawing geometry; applied, such as engineering graphics; and technological – computer graphics and three-dimensional modeling.

The task of descriptive geometry is to familiarize with the general theory and methodology of geometric models, objects and processes building.

The main task of engineering graphics is to provide students with a conceptual apparatus during the construction and design of technical drawings, as well as the creation of technical and technological documentation in accordance with standards.

Computer graphics and modeling introduces students of a higher educational institution to the process and technology of creating electronic design and technological documents, professional terminology, types and virtual computer models structures. The main task of the discipline is to obtain the skills of three-dimensional electronic models creating and forming the skills of technical and technological documentation figuration in certain CAD.

The choice of CAD software is an important factor that ensures the students' professional competencies successful formation when mastering 3D modeling skills.

The automated design system used for the training of future professional personnel must meet the following basic requirements [4]: perspective of the software products; their competitiveness and prevalence in business markets; adaptation to the requirements of native normative documents; availability of educational versions; pricing policy of the system developer; compliance with the tasks facing future specialists and their professional competencies.

One such system, which was used during student training, is the high-level Creo Parametric software complex. This CAD system allows you to quickly elaborate high-quality and accurate 3D models of design objects containing both simple and fairly complex geometric surfaces. The digital models developed are fully associative, since any changes made to the model or accompanying process documentation lead to a comprehensive update of all detailed design documentation.

The main advantages of Creo Parametric over many other software products are: increase of labor productivity due to efficient and flexible functions of three-dimensional computer modeling; any complexity degree quick parts or assemblies 3D-models creation; production and technological documentation automated creation, which ensures the current design of the model full compliance; possibility of trouble-free working with other formats data, obtained from third-party CAD systems; standard product libraries availability; availability of training materials.

Various modules of this software complex allow structural, thermal, kinematic and other types of design analyses and created structures optimization.

The Creo Elements module allows you to solve problems and optimize the created computer model of a mechanical part or assembly unit, or an electrical product by strength, thermal or kinematic characteristics, without resorting to the production of full-scale samples. This allows you to optimize the design in several parameters, defining the necessary characteristic as the target function: cost, weight, heat flow, temperature gradients, etc.

The Creo ECAD module allows parametric design of electronic PCBs, helps to develop the electronic components layout, create and lay three-dimensional cable electric harnesses inside the assembly unit model at the same time as developing their fastening mechanical design.

Product’s three-dimensional computer model creation is the most important step in its design, since it largely ensures the efficiency of the method of its manufacture, as well as the quality of the final result of the entire design process.

At the same time, a powerful modern CAD systems use in training 3D-modeling most often leads to the emphasis of the trained contingent on the interfaces of these software products and the capabilities provided by them, rather than on the development and improvement of visual spatial thinking. At the same time, a necessary operations algorithms machine memorization, which a studied software makes it possible to carry out, most often leads to excessive automation of actions performed when creating or analyzing the object model designed. Advanced spatial thinking ultimately significantly impacts performance and 3D modeling tasks performing efficiency.

To develop the future specialist’s visual-spatial modeling skills, a different complexity levels tasks system can also be developed, organized according to the principle of "from simple to complex".

First-level tasks should be the simplest, requiring students to create or convert 3D-models from simple geometric shapes or, as they are called, primitives. Solving this level task should be based on the ability to represent the created object by connecting or moving simple forms. Mastering this training stage will allow you to hone the working in a three-dimensional graphic editor skills and will give you the opportunity to effectively cope with those tasks for which the previously developed models can be used as work pieces.

The next most complex level of tasks is based on the modification of pre-created simplified models, from which you can get the final shape of the product. When solving these problems, it is necessary to create a new with a parts work piece 3D-model made on the polygon grids basis, affecting either the entire work piece or its individual elements.

High-level tasks are designed to obtain more complex models consisting of modified objects and ready-made shapes with the addition of a transformation of their geometry, which will allow you to get a new model shape from the existing.

The last level of tasks contains tasks that require the creation and/or analysis of non-static models in space or in time, as well as models exposed to different types of external influences. When solving these problems, it is necessary to take into account the influence of various environmental factors.

However, during the future professionals training, in no case should we forget about the general pedagogical principles [4] of the organization of the modern educational process: scientific, fundamental, systematic, systematic and consistent, theory-to-practice, professional focus, accessibility and visibility.

The principle of science speaks of the need to use the latest modern achievements in the field of science and technology to organize the educational process at a technical university.

In accordance with the principle of fundamentality, students should obtain a theoretical knowledge base for their qualitative and comprehensive educational training, which will provide a wide general outlook and a high professional level.

On the principle of system, students should be provided with a high quality of the obtained knowledge, characterized by the presence of structural relationships between different educational disciplines. In addition, on this principle, future professionals should learn the educational material taught to them in sufficient volume for professional activity, which will make it possible to achieve high professional results more fully and in less time.

The systematic nature of studying is closely and inextricably related to the previous principle and is the methodological basis of the general didactic principle of studying sequence.

The students training professional orientation is a comprehensive unity of students, theoretical scientific knowledge and professional skills by implementing a corresponding set of pedagogical and methodological techniques that create a solid basis for the comprehensive student's development and their achievement on this basis the necessary professional training practical goals. Teachers participation in scientific research using 3d modeling technologies to solve problems that have arisen at the enterprise, provide training methodological techniques professional orientation [9, 10].

According to the principle of accessibility, any educational disciplines material offered to higher educational institution students should be relatively simple, open and understandable for its successful studying.

The principle of visibility should provide a sensual basis for successful mastering of relevant abstract concepts.

The teaching disciplines practice related to computer modeling technologies showed a noticeable increase in interest in studying in this direction among students after the KrNU representative's participation in the II round of the full-time All-Ukrainian Olympiad in CAD and computer modeling. Meetings with the Olympiad partner company's representatives caused a great impact on interest in studying. Partner companies of the Olympiad are employers at the same time. Therefore, most tasks at the Olympiad are part of real production tasks. At the same time, participation in Olympiads forms the spirit of healthy competition and competition among the most gifted youth.

IV. CONCLUSION

The use of technology and elements of 3D-modeling in the process of the student's professional training due to a wide range of its functions contributes to the future professional's practical training improvement, which leads to better mastering of technical specialties.

The use of digital information technologies in general and three-dimensional computer modeling in particular makes it possible to intensify the educational process in a higher educational institution by increasing the students interest in learning and actively mastering the sections of computer disciplines by students.

High quality of engineering specialist training is achieved through a multi-level educational process. The number of training levels cannot be less than three. The complexity of tasks that students solve during their studies is gradually increasing. Training tasks at the end of training practically do not differ from the tasks of real manufacturing. The training tasks of the final course should be formed in cooperation with potential employers.

Student's participation in computer modeling technologies competitions in significantly stimulates interest in students to master new knowledge. Relevant in this process is the potential employer's participation.

In addition, the relevant academic disciplines educational programs development allows students to use the acquired knowledge and skills in the practical tasks implementation, both in junior and senior courses during their education along individual educational trajectories.

REFERENCES

[1] E. Y. Tereshchenko, I. A. Koryagina, M. N. Rudenko and Z. A. Kevorkova, V. A. Yelistratov, "Methodological Basis of Business Value Estimation," International Journal of Applied Business and Economic Research, 2017. №11, pp. 11-18.

[2] V. S. Kungurtseva and A. B. Titov, "Trends and problems of innovative development of information and communication systems in the context of a digital economy," Scientific and Technical Bulletin of SPbSPU. Economics. 2018; 11(1):54-63. DOI: http://doi.org/10.18721/JE.11105 (In Russ.).

[3] V. A. Lokalov, I. V. Klimov, Yu. O. Konstantinova and A. S. Mironov, "Methodical features of preparation of computer technologies in the system of additional education," ITMO University, 2020. – 53 p. (in Russ).

[4] V. N. Guznenkov, "Prepodavanie informatsionnykh tekhnologiy v graficheskikh distsiplinakh tekhnicheskogo universiteta," Otkrytoe obrazovanie. 2013. No 1. pp. 4–7 (in Russ).

[5] T. N. Suvorova, and E. A. Mikhlyakova, "Application of technologies 3D-modeling for the personalization of training," Scientific and methodological electronic journal "Concept", Vol.. 5, 2020. pp. 110-129.

[6] S. O. Korol, M. M. Moroz, S. S. Korol, V. O. Yelistratov and O. V. Moroz, "Development of a Moderator of the Pump Controlled Drive for the Engine," International Conference on Modern Electrical and Energy Systems (MEES), Kremenchuk, 2019, pp. 30-33.

[7] M. M. Moroz, S. O. Korol, V. O. Yelistratov, S. S. Korol, O. Moroz, and V. Zahorianskyi, "Device for stabilizing the electrical power of a diesel generator in transport," International Conference on Modern Electrical and Energy Systems (PAEP), Kremenchuk, 2020, pp. 1-6.

[8] A. P. Ershov, G. A. Zvenigorodsky and Yu. A. Pervin, "School informatics (concepts, state, prospects)." Novosibirsk, 1979. - 51 p. - (Prep. Of the Academy of Sciences of the USSR, Siberian Branch; Computing Center; № 152). School computer science; Issue I. - P. 4 // Archives of Academician A.P. Ershova [Electronic resource]. Folder 167. Forecast for the most important area of science "School Informatics". Articles, interviews. L. 158. - Access mode: http://ershov.iis.nsk.su/archive.

[9] S. Chernenko, E. Klimov, A. Chernishl, O. Pavlenko and V. Kukhar, "Simulation Technique of Kinematic Processes in the Vehicle Steering Linkage," International Journal of Engineering & Technology, Vol. 7, No 4.3, Special Issue. 3, pp. 120-124 (2018). DOI:10.14419/ijet.v7i4.3.19720.

[10] O. Pavlenko, S. Dun, O. Kharkov, R. Puzyr and V. Shapko, "Analysis of the stress state of the 4-axle dump truck lifting mechanism hydraulic cylinder support," Transportation Research Procedia Volume 63, 2022, pp. 347-359. DOI: 10.1016/j.trpro.2022.06.022.