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ANALYSING THE FEATURES OF CAD APPLICATION IN THE EDUCATIONAL PROCESS

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АНАЛІЗ ОСОБЛИВОСТЕЙ ЗАСТОСУВАННЯ САПР В ОСВІТНЬОМУ ПРОЦЕСІ

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The high dynamism of all social processes and phenomena determines the formation of a new worldview system for humanity, the modification of the hierarchy of needs and values and challenges to the pace and quality of development. Solving highly complex tasks related to meeting modern requirements demands the use of the latest scientific solutions and tools. Therefore, robotics, automation, and digitalization, which are based on advanced intellectual technologies, are considered to be the driving forces behind the innovative and technological structure. Humanity also has to solve a number of complex problems related to ecology, the search for new sources of energy, materials, and technologies that are acceptable to society. High information technologies play a decisive role in solving these problems. Among information technologies, design automation occupies a special place in the educational process. Firstly, design automation is a discipline that incorporates many other modern information technologies. For example, the technical support for computer-aided design (CAD) systems is based on the use of computer networks and telecommunications technologies, and CAD uses personal computers and workstations. The mathematical support of CAD systems is distinguished by the richness and diversity of methods of computational mathematics, statistics, mathematical programming, discrete mathematics, and artificial intelligence. CAD software packages are among the most complex modern software systems based on operating systems, complex programming languages, and other modern CASE technologies. Secondly, knowledge of the basics of design automation and the ability to work with CAD tools are necessary for virtually any future design engineer. This article examines the issues and problems students encounter when studying high-tech disciplines. In today's environment, higher education institutions (HEIs) need a high-quality and technologically advanced new approach to training students at different levels of education. The introduction of high-tech disciplines into teaching allows for the rapid development and offering of a variety of individual assignments on a wide range of topics to students, taking into account their initial level of computer literacy. With the right approach, CAD can be an excellent basis for introducing project-based learning into the educational process. In addition, the use of automated design systems in the educational process, along with solving the main task, provides a number of additional educational effects. The combined effect of these factors significantly improves learning outcomes. This article discusses some of the distinctive features of CAD that have a positive impact on the effectiveness of training modern specialists.

Keywords: *design, technical specifications, mathematical model, methods, modeling, cognitive process.*

Introduction. The last few decades have been marked not only by the rapid development of computer technology, but also by the emergence and subsequent rapid development of a new field of knowledge based on it, which is now commonly referred to as IT technologies. IT technologies are widely used in the educational process at higher education institutions: electronic textbooks, multimedia systems, computer programs, knowledge control systems, distance learning systems, and much more. Along with the above-mentioned tools, so-called computer-aided design (CAD) systems, which are packages of application-oriented programs, are increasingly being used for educational design purposes. The issue of their application in the educational process deserves close attention, since in manufacturing, the results

of implementing the latest CAD-based technologies in the design of the most complex products have long proven their advantages over traditional methods.

Nowadays, no major development in mechanical engineering, energy, or electronics can do without automated design systems. The term «CAD» itself has become synonymous with characteristics such as high precision and high design speed. In these conditions, there is an obvious need for some adjustments to university educational programs. Currently, the most important competencies of university graduates in engineering specialties and training areas include the ability to use application software packages for device analysis and synthesis [1].

In addressing this issue, universities today face a number of serious challenges related to insufficient material resources (lack of powerful computers, high cost of licensed software, etc.). However, a number of large CAD software companies offer (free) «cut-down» student versions of CAD software, which can be a great help in learning.

Studying modern CAD systems and acquiring skills in working with them will undoubtedly contribute to improving the quality of engineering training, significantly reduce the time needed for young specialists to adapt to the workplace after graduating from university, and significantly increase their demand among employers. In addition, the use of computer-aided design systems in the educational process, along with solving the main task formulated above, provides a number of additional educational effects, the combined effect of which significantly improves learning outcomes. Let us consider some of the distinctive features of CAD that have a positive impact on the effectiveness of training modern specialists.

Presentation of the main material.

System for designing systems. According to definition [2], CAD is a set of tools and methods for automated design. It includes several components (subsystems) called technical, mathematical, software, linguistic, information, methodological, and organizational support. It is important to note that CAD is a «human-machine» system. The team of developers is part of the design system that performs design work in interaction with a computer. This feature of CAD most naturally contributes to the development of teamwork skills in students, which is one of the most important requirements of educational standards.

It is very important that all CAD systems are designed for designing not individual parts or components, but the entire system as a whole. Thus, when starting to work with CAD, students gain an understanding of the most complex manufacturing process of design from the very first step. He learns to draw up technical specifications, familiarizes himself with the design features of the future system, draws up drawings, selects materials and components for its implementation, etc. CAD systems allow you to simulate the operation of equipment and have tools for analyzing the processes occurring in the model. This provides students with the opportunity to analyze results interactively, compare them with technical specifications, and make adjustments to the initial data if necessary. At the same time, students are engaged in real creative engineering work. The intermediate and final results of CAD are calculated taking into account the interaction of individual elements of the designed system, thereby contributing to the most important process of synthesizing the knowledge acquired by the student in the early stages of training. The synthesis of fragmented knowledge instills a systematic approach that is so necessary for the developer of complex technology.

Project-based learning. With the right approach, CAD can be an excellent basis for introducing project-based learning into the educational process [3]. The essence of this approach is that the teacher sets the initial data and formulates the planned results of the learning task. Students set their own intermediate tasks, look for ways to solve them, and, while working on the project, compare the results obtained with the required ones and, if necessary, adjust the parameters. As a result, they acquire the skills to independently «acquire» new knowledge, learn to apply it to solving practical problems, and gain their first experience in research work.

The role of the teacher in such a situation boils down to guidance, counseling, and correction. At the same time, the requirements for teacher qualifications when working with the project method are extremely high. Nowadays, it is no longer sufficient to require teachers to have knowledge and experience working with CAD, or the ability to act as a coach who plays. Their role is much more complex. The fact is that this teaching method involves breaking the traditional sequence of studying the didactic units of the course. Students have the opportunity to independently formulate learning tasks for themselves in accordance with the specifics of the project, plan and solve them in the

sequence necessary for its implementation. At the same time, there is a risk of «missing» important sections of the course. There are other risks. For example, it is unacceptable for a student to master the rules of using CAD without learning the design methods programmed into the system. Therefore, the introduction of a project-based learning method based on the use of modern CAD systems can yield progressive results, but requires a very balanced approach and the participation of highly qualified teachers.

Mathematical models and CAD capabilities. When studying physical or engineering disciplines, mathematical descriptions of processes often encounter significant difficulties in understanding the results obtained and physically interpreting expressions and formulas. In these cases, numerical (computer) modeling comes to the rescue. The model allows not only to perform the calculation part, but also to correctly interpret the results obtained and gain a deeper understanding of the processes being studied. From an educational point of view, the process of creating such mathematical (obtaining formulas, developing algorithms) and computer (writing and debugging programs) models is one of the most important and effective stages in studying the discipline. Unfortunately, it is rarely possible to set students the task of developing a serious model, as the curriculum does not always provide the necessary number of hours for this work. Teachers who choose this approach are forced to take drastic measures, reducing the scope of the task and using approximate methods to solve the problem. In these cases, it is advisable to consider using commercial software as CAD. Working with it does not require any effort to develop a model; students only need to learn the rules of operation. This will allow them to focus on the design process, on studying and analyzing the results obtained, and, possibly, on the procedure for optimizing the solution obtained.

At the same time, working with CAD has its «dark» side. Without being directly involved in creating a mathematical model, students only get a rough idea of its features and how to solve problems. Usually, their work boils down to correctly describing (computer drawing) the designed product. After that, the necessary CAD operations are performed automatically. As a result, there is a risk of superficial mastery of the theoretical foundations of the discipline. However, the effort saved in creating the model allows you to go much further in the project development process.

When analyzing the possibilities of applying CAD in the educational process, it is worth remembering that the first attempts to automate design processes often encountered obstacles related to insufficient computing resources (low computing speed, small amounts of RAM, primitive interface). These limitations forced CAD developers to create systems based on more primitive models that used approximate methods to describe the designed products. That is why, initially, such systems did not differ much from educational models.

The rapid pace of development in computing technology gradually allowed restrictions on the degree of design automation to be lifted. Increased speed, greater «power» of automated design systems, and expansion of their capabilities are not the only and most important results of progress in IT technology. The most important result was the possibility to start creating CAD systems based on more advanced mathematical models that most adequately describe complex physical processes, taking into account numerous connections, material properties and their changes during operation, environmental impact, etc. As a result, the improvement of models and CAD systems based on them has led to an increase in the reliability of design results, while the development of tools for analyzing and optimizing the results obtained, as well as the creation of user-friendly interfaces, has dramatically increased the efficiency of designers' work.

The decision on how best to organize educational design—using CAD or based on simplified models created by students—should be made by the department. This decision requires a balanced approach, consideration of all the pros and cons, and places high demands on the qualifications of the teaching staff.

Returning to the learning process, it should be emphasized that working with CAD allows students to immerse themselves in an atmosphere close to the conditions of their future work in real production. The results of their projects will not be just abstract structural diagrams, formulas, and numbers, but specific device designs made from real elements and materials. CAD allows students to evaluate the performance characteristics of their designed devices in real conditions, including when external parameters change, to estimate the necessary production costs, etc. This is a significant step forward in training specialists to meet the demands of modern manufacturing. Aligning educational tasks with the needs and capabilities of production is a very pressing issue at present.

During the design process, students have the opportunity to conduct small-scale research aimed at finding the optimal solution.

Working with CAD as a cognitive process. Educational design using CAD significantly expands cognitive capabilities. This is facilitated by the design mechanisms and display of results built into these systems. Virtually all modern automated design systems allow the visualization of complex physical processes that cannot be observed under normal conditions [4].

It should be noted that all CAD systems allow, after creating a spatial computer model, to examine it comprehensively, see the "invisible" side, study the details and components located inside the block, and better understand their mutual arrangement. In other words, the design system forms an adequate detailed image of the product being created.

Computer interactive modeling based on CAD as virtual laboratory work. The transition to new educational standards required a review of the ratio of classroom hours to independent study hours in favor of the latter. At the same time, it is obvious that reducing the number of laboratory classes in most disciplines will negatively affect the quality of training. A compromise could be to perform virtual analogues of laboratory work, which involve computer modeling [5]. CAD can also be a very useful tool in this case and form the basis for creating laboratory work. It is important to note that it can be organized remotely, which eliminates the need to install CAD on each student's computer.

Tool for increasing motivation to learn. Teachers are encouraged to «develop independence, initiative, and creative abilities in their students». This is a difficult task. One of the most important conditions for its fulfillment is increasing students' motivation to study in their chosen field. Experience in organizing the educational process for both bachelor's and master's degree students demonstrates the positive role of CAD in increasing student interest in studying the subject. Work engages students in the most interesting process of creation with a computer and a «smart» automated design program in dialogue mode from the very first steps. This psychological feature must be taken into account at school age. It is no coincidence that the special term edutainment, which means acquiring knowledge through play, originated abroad and is becoming increasingly popular. In the vast majority of cases, such "adult play" contributes to increasing students' interest in their future profession.

The vast capabilities of CAD give students the confidence that they can tackle serious projects. Indeed, if universities involved students extensively in fulfilling orders from enterprises for the development of new technology, students would feel like equal participants in the scientific research or experimental design work carried out by the university. Many would feel the need to be creative, to realize their own ideas and create their own developments. A number of US universities have a system in place to support such student initiatives and promote them on the market. In this case, the intellectual property belongs to the student and the university; the income from the sale of such developments accounts for a significant share of the university's budget.

Conclusions. The analysis of the features of applying automated design systems in the educational process is based on real experience in teaching a number of technical disciplines, which, according to modern terminology, can be attributed to the field of high technology. The results of the observation, although exhaustive, convincingly demonstrate a number of positive effects. The most valuable thing about them is the answer to the question of how to ensure that future bachelors and masters acquire a whole range of essential professional competencies, including both the competencies formulated in Ukrainian educational standards and the quality criteria for engineering education set out in the requirements of foreign and international accreditation organizations.

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Давіденко Н. О., Карпюк Л. В., Кобзарев Е. В. Аналіз особливостей застосування САПР в освітньому процесі

Висока динамічність усіх суспільних процесів і явищ обумовлює формування нової системи світогляду людства, модифікацію ієрархії потреб і цінностей, викликів до темпів та якості розвитку. Вирішення надскладних завдань, пов'язаних із задоволенням вимог сучасності, вимагає застосування новітніх наукових рішень та інструментів. Відтак рушійними силами інноваційно-технологічного укладу визначають робототехніку, автоматизацію, цифровізацію, основою яких є високі інтелектуальні технології. Людству також доводиться вирішувати низку складних проблем, пов'язаних з екологією, пошуком нових джерел енергії, матеріалів, технологій, що відповідають суспільству. Визначальна роль у вирішенні названих проблем відводиться високим інформаційним технологіям. Серед інформаційних технологій автоматизація проєктування займає особливе місце в освітньому процесі. По-перше, автоматизація проєктування – дисципліна, її складовими частинами є багато інших сучасних інформаційних технологій. Так, технічне забезпечення систем автоматизованого проєктування (САПР) засновано на використанні обчислювальних мереж і телекомунікаційних технологій, в САПР використовуються персональні комп'ютери і робочі станції. Математичне забезпечення САПР відрізняється багатством і різноманітністю методів обчислювальної математики, статистики, математичного програмування, дискретної математики, штучного інтелекту. Програмні комплекси САПР належать до числа найбільш складних сучасних програмних систем, заснованих на операційних системах, складних мовах програмування і інших сучасних CASE-технологіях. По-друге, знання основ автоматизації проєктування і вміння працювати із засобами САПР потрібні практично будь-якому майбутньому інженеру-розробнику. У даній статті розглядаються питання та проблеми навчання студентів, з якими вони зустрічаються під час вивчення високотехнологічних дисциплін. У вищих навчальних закладах (ВНЗ) в сучасних умовах потрібен новий підхід до підготовки студентів різних рівнів навчання − якісний, технологічний. Впровадження високотехнологічних дисциплін в навчання дозволяє досить швидко розробляти та пропонувати студентам різноманіття варіантів індивідуальних завдань за великою кількістю тем з урахуванням рівня початкової комп'ютерної підготовленості студентів. При правильному підході САПР може бути прекрасною основою запровадження у освітній процес проєктного способу навчання. Крім того, використання у навчальному процесі систем автоматизованого проєктування, поряд з рішенням основного завдання, дає низку додаткових освітніх ефектів. Сумарна дія таких ефектів багаторазово покращує результати навчання. В даній статті розглядаються деякі відмінні риси САПР, які позитивно впливають на результативність підготовки сучасного спеціаліста.

***Ключові слова**: проєктування, технічне завдання, математична модель, методи, моделювання, когнітивний процес.*

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