The article discusses the problems of teaching students engineering and computer graphics in a single course based on a computer-aided design (CAD) system. Examples of training tasks for acquiring knowledge, skills, and abilities in the environment of the drawing and graphic editor of the AutoCAD system are given. They are necessary when performing drawings on engineering graphics, as well as the graphic part of course projects for students of mechanical specialties. Examples of exercises for self-study of the material are considered for a deeper study of the drawing-graphic module structure of the system and the acquisition of skills to work with its tools. The article also discusses several topics for studying the graphical editor AutoCAD, it reveals their contents and provides methods for completing practical tasks.

A comprehensive training program extends the ability of teachers to submit material, increases students' interest in graphic disciplines, so it can achieve better results in their development. However, there are a number of problems with this approach. Different levels of basic knowledge of students in the field of computer technology require greater individualization in the organization of the educational process. An additional burden for the teacher is to check the electronic drawings and to control the independence of students' work when performing graphic works using CAD. Combining engineering and computer graphics requires more intensive work from students.

It is noted that the implementation of the proposed set of tasks is only the first stage of training students in computer technologies for creating design documentation. The acquired knowledge, skills, and working skills in the environment of the AutoCAD system will be in demand when studying modern means of three-dimensional modeling. The execution of drawings using computer tools is undoubtedly more attractive to students, compared to traditional drawing.

It is also important to create conditions for actualizing the intellectual potential of students, as well as the formation of positive motivation. Enthusiastic students independently master the functions of the system that are not intended for study by the curriculum. They participate with pleasure in Olympiads in engineering and computer graphics.

Ways of improving the verification of graphic works by a teacher are developed. A partial solution to the problem of checking the graphic part of course projects using preliminary drawings in a draft version and intermediate printouts of their electronic versions are proposed.

**Key words:** engineering and computer graphics, graphic editor of the AutoCAD, design documentation, modern means of three-dimensional modeling.

**Introduction.** The development of computer aided design, the gradual transition from paper documentation to electronic causes the need to modify the study of disciplines of the engineering-graphic cycle. In accordance with the curricula of preparation of bachelors in such specialties as 133 «Branch of mechanical engineering», 161 «Chemical technologies and engineering», the study of computer technologies of creation of design documentation begins from the first year of study of students within the course of engineering graphics. In this regard, the working curricula of the disciplines «Engineering Graphics» and «Engineering and Computer Graphics» include sections for learning the rules and mastering the rules of design documents in the environment of the automated system of design AutoCAD.

**Statement of basic materials** A comprehensive training program extends the ability of teachers to submit material, increases students' interest in graphic disciplines, so it can achieve better results in their development. However, there are a number of problems with this approach. Different levels of basic knowledge of students in the field of computer technology require greater individualization in the organization of the educational process. An additional burden for the teacher is to check the electronic drawings and to control the independence of students' work when performing graphic works using CAD. Combining engineering and computer graphics requires more intensive work from students.

For this purpose, two classes of graphics equipped with computers, an interactive whiteboard, and a plotter were created at the Department of Mechanical Engineering and Equipment of Industrial Enterprises of Volodymyr Dahl East Ukrainian National University named after.

The interactive whiteboard allows you to present the material clearly, accessible and in full. Students find
the material easier and more interesting. Experience shows that the introduction of interactive whiteboard training brings positive results in the study of such graphic editors as AutoCAD, SolidWorks and other programs. Automated methods of working with the drawing and other documents do not exclude the need for knowledge and understanding of the theoretical foundations and provisions of the course.

So, in the first semester, students study descriptive geometry as the basis for the construction of the drawing, the elements of its design [1]. In the second semester, the discipline program provides for the implementation of sketches and drawings of parts, the study of the rules for applying dimensions, surface roughness, thread designation, images of detachable joints, welded joints, design of assembly drawings and specifications [2,3].

Computer technologies for the development of design documentation are used by students in carrying out a number of individual graphic assignments and the graphic part of course projects in the disciplines «Machine Details» and «Theory of Mechanisms and Machines», while being an independent object for study. Thus, the skills are acquired to perform drawing and graphic work in a traditional and modern, computer way. For independent study of all sections of the discipline, students are provided with various reference materials and manuals [3, 4, 5], both in print and in electronic form. Further, in the course design, students develop a set of design documentation for the assembly unit completely in an automated environment.

In the context of a comprehensive training program, practical classroom studies are aimed at solving two problems simultaneously: studying the rules for designing and developing design documentation, as well as the basic principles for performing electronic drawing in AutoCAD, a system drawing and graphics editor. Various methods of supplying educational material are used. These are lectures prepared on the basis of demonstration computer systems, posters and full-scale samples, as well as exercises to study the AutoCAD system, performed by students simultaneously with the teacher in the master class mode.

In addition to intensive classroom work, the solution to the problem of assuming the planned amount of information is the active and competent use of the capabilities of the AutoCAD complex when performing individual graphic works. Its settings and numerous applications are based on the standards of the Unified Design Documentation System (UDDS) [5]. The use of the system as a tool for obtaining high-quality graphic documentation allows to reduce labor costs and, in general, significantly improve the design training of students.

For a deeper study of the structure of the drawing and graphic module of the system and the acquisition of the skill to work with its tools, students are invited to perform a number of exercises on their own. For these purposes, teachers of the Department of Mechanical Engineering and Equipment of Industrial Enterprises of Volodymyr Dahl East Ukrainian National University developed methodological guidelines and teaching aids, which, along with a brief description of the program’s capabilities and recommendations for their practical application, include exercises that are step-by-step instructions for completing training tasks that contain typical elements graphic and text design documents [3, 4].

The theme of the study of the system "Basic concepts of the graphical editor AutoCAD. Building primitives «includes exercises aimed at studying the system interface, toolbars, various system settings, for mastering the basic system commands and methods for creating detail drawings, saving and printing documents. We study ways to enter commands for building primitives. A number of fundamental differences between the algorithm for creating a drawing on a computer and traditional drawing on a culmination are considered [3, 4, 6]. Images 1 and 2 contain fragments of exercises on this topic.

**Task.** Construct a rectangle by specifying points in absolute coordinates.

**Command:** Line

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**Fig. 1. Construction of a rectangle**

**Task.** Construct a cam according to the specified dimensions. Circle the polyline.

**Fig. 2. Construction of a cam**

The topic of Editing Drawing Elements includes exercises that allow you to learn the commands of editing primitives and created drawings. It considers editing methods, object binding, text creation and modification [3, 4, 6]. Performing these exercises, students practice various methods of obtaining images, get acquainted with the commands of the AutoCAD system and the principles of working with them. The following are fragments of exercises (image 3, image 4). The form of exercises allows you to independently learn
Step by step the structure of the system and acquire the skill of working in its environment.

**Task.** Construct two arcs by tying their end points.

Fig. 3. Construction of arcs

**Task.** Draw an equidistant (similar primitives at a distance of 5 mm).

Fig. 4. Construction of equidistant

After completing these exercises, students will learn how to develop assembly drawings using the capabilities of the AutoCAD system design library when displaying standard fasteners. In the process of performing such exercises, students not only get acquainted with the structure and contents of the library, but also acquire initial design skills by «collecting» standard compounds from their components in a certain sequence [3, 4, 6].

**Task.** Perform the drawings at the specified sizes using layer-by-layer distribution.

The next topic for the study of AutoCAD graphical editor «Instructions for the design of drawings» allows you to study the settings of dimensional styles, text styles, zooming, hatching, working with utilities (control variables), applying tolerances, deviations, surface roughness of the part, material designation [3, 4, 6]. The following are fragments from exercises (image 5, image 6).

Fig. 5. Hatching

The Theme «Properties of primitives. Creating Blocks» contains instructions for using such service capabilities of the system as layer-by-layer product design, the use of fragments in the formation of a drawing. It introduces techniques for creating parametric objects and the features of working with them, allows you to understand the essence of library elements of the system and, in the future, the formation of models for your own libraries. Using blocks, you can create your own database, which can be used to create drawings. The following is a fragment of the exercise (Image 7).

Fig. 6. Layout of the base size

Fig. 7. Drawings using layer distribution

The next stage in the study of the AutoCAD graphic editor is the theme «The most comfortable parts to the UDDS». Using the previously acquired knowledge, the student must create a drawing of the part in the sequence that is proposed in this topic, draw up the drawing in accordance with the requirements of the Unified Design Documentation System (UDDS) [5]. Image 8 shows an example of one of the exercises on this topic.

On the topic «Specifications», there are exercises that are designed to acquire the skill of drawing up specifications, both in manual and automated mode [3, 4]. The acquired skills are used in the development of assembly drawings and directly in the course project on the discipline «Machine parts». An intermediate control is provided for students to master the system’s functionality considered in exercises. To successfully complete the tasks you need not only knowledge of the AutoCAD
system and the skills to work in it (methods for constructing a part outline, setting system elements, the ability to control image scale and drawing scaling, using text templates), but also the basics of descriptive geometry. Thus, the interconnection of the sections of the engineering graphics course is maintained.

The experience gained will allow students to quickly master more complex graphic software products used in enterprises of various industries, in research and development organizations.

Conclusions. In conclusion, it is noted that a feature of the educational process in the discipline «Engineering Graphics» has always been a high degree of individualization of training, due to the personal nature of graphic tasks, as well as the significant complexity of the implementation and verification of these tasks.

The problem of the complexity of checking graphic works and controlling knowledge becomes even more relevant with an integrated approach to training students in engineering and computer graphics. Checking the electronic drawing significantly increases the load on the eyesight. The inability to often see the entire drawing on the monitor screen at a scale convenient for work increases the time to check the drawing. Finally, there are the difficulties when checking the remarks of a teacher in an electronic document. And, as a consequence, untimely correction of errors increase the number of students’ requests for advice several times. This problem is partially solved by preliminary execution of the sketch drawing and intermediate printouts of its electronic version. The implementation of the preliminary design of the assembly drawing layout is an obligatory stage of work on the project in the course design. This allows the teacher to evaluate the independence of the student’s work at the first stage of design and to reduce the likelihood of duplication of ready-made assignments. An analysis of the problems in the educational process when studying the discipline «Engineering and computer graphics» allows us to recommend in the standards for calculating the academic load to limit the number of students in the group per teacher and to increase the number of hours allocated for consultations.

References


Literatura

Карпюк Л. В., Давиденко Н. О. Комп’ютерна практика в інженерній графіці

У статті розглядаються проблеми навчання студентів інженерної та комп’ютерної графіки в рамках єдиної курсу на базі системи автоматизованого проектування (САПР). Наводиться приклад тренувальних завдань для прибуття знань, умінь і навичок роботи в середовищі креслярсько-графічного редактора системи AutoCAD, необхідних при виконанні роботи з інженерної графіки, а також графічної частини курсових проектів для студентів механічних спеціальностей. Для більш глибокого вивчення структури креслярсько-графічного модуля системи та прибуття навичок роботи з іншими інструментами розглядається приклад виконання вправ для самостійного вивчення матеріалу. Також розглядаються більш глибока тема з вивчення графічного редактора AutoCAD, самостійно виконання їх змісту і наводяться методи виконання практичних завдань.

Комплексна програма навчання розширює можливості викладачів в подачі матеріалу, підвищує інтерес студентів до графічних дисциплін, також чим дозволяє досягти кращих результатів в їх освоєнні. Однак при такому підході виникає ряд проблем. Різкий рівень базових знань студентів в області комп’ютерних технологій вимагає більшої індивідуалізації в організації навчального процесу. Додатковим навантаженням для викладача є перекриття електронних ресурсів і здійснення контроль особистості роботи студентів при виконанні графічних робіт з використанням САПР. Об’єднання інженерної та графічної подачі студент глини більшій індивідуалізації виконання роботи від студентів.

Відповідно, що виконання запропонованого комплексу завдань - лише перший етап навчання студентів комп’ютерним технологіям створення конструкторської документації. Набуті знання, уміння і навички роботи в середовищі системи AutoCAD будуть зберігатися при вивченні сучасних засобів виробництва чертежів. Виконання роботи з використанням комп’ютерних засобів, безумовно, більш привабливе для студентів, як правило, з інженерними спеціальностями. Важливо й створення умов для актуалізації інтелектуального потенціалу студентів, а також формування позитивної мотивації. Закінчені студії самостійно освоюють функції системи, які не були передбачені для виконання програми курсу, і з задоволенням беруть участь в олімпійцях інженерної та комп’ютерної графіки.

Пропонуються шляхи удосконалення перекриття графічних робіт викладачем і часткове вирішення проблеми перекриття графічної частини курсових проектів за допомогою відповідного виконання виконання в екземпляр варіантів і пропоненими розробниками їх електронних версій.

Ключові слова: інженерна та комп’ютерна графіка, графічний редактор AutoCAD, приклад, конструкційна документація.