# USE OF COMPUTER-INTEGRATED TECHNOLOGIES IN TRAINING OF ENGINEERING SPECIALISTS

***Vasyl Vasylkiv, Myhajlo Pylypets, Larysa Danylchenko, Dmytro Radyk***

*Ternopil National Ivan Puluj Technical University, Rus'ka str. 56, 46001, Ternopil, Ukraine; snt.tu.edu@gmail.com*

**Abstract:** The article considers the peculiarities of the use of computer-integrated technologies (CIT) for the training of specialists in engineering and technical specialties, analyzes the latest research and scientific publications on the introduction of information technologies in the educational process of higher technical educational institutions. Based on the theoretical analysis of scientific sources on the essence of CIT, the specifics of training future engineers and the study of practical experience, the scientific and pedagogical conditions for the use of computer-integrated technologies in the educational process were determined. The role, tasks and possibilities of CIT introduction for mastering engineering and technical disciplines are determined. Approaches to understanding the readiness of future engineers to use CIT during training are generalized. The peculiarities of the introduction of computer-integrated technologies in the educational process of training specialists of higher educational institutions in the specialty 131 "Applied Mechanics" are considered, the structuring of educational programs in this specialty is carried out. Ways to increase the efficiency of training of engineering skills in the specialty 131 "Applied Mechanics" given the widespread use of software products for mastering engineering disciplines.

**Keywords:** *educational process, computer-integrated technology, application software*

## 1. Introduction.

Fierce competition in the labor market of Ukraine and the economic conditions in which the state finds itself have exacerbated the problem of training graduates of higher education institutions. The main problem is the discrepancy between the socially necessary and the actual levels of training. At the present stage of the development of society, the volume and complexity of information flow is quite large and increase every year. Today, the use of modern CIT in education is one of the most important and sustainable trends in the world educational process, which is considered an expectable development of the informatization of all spheres of human activity. The process of informatization of education has acquired a purposeful character of national importance, due to modern requirements for training of future engineers, defined by the Laws of Ukraine "On Higher Education", "On Basic Principles of Information Society Development in Ukraine", the National Doctrine of Education Development of Ukraine in the XXI Century, the National Informatization Program, the State Program "Information and Communication Technologies in Education and Science".

The modern development of post-industrial states is characterized by the continuous increase of new knowledge, the strengthening of the intellectualization of labor, and the expansion of high technologies. This necessitates an acute problem for qualified engineering personnel for all industries. Higher education faces the task of training future engineers acquainted with the concept of CIT, able to form a strategy for automation of production, ensuring their competitiveness and professional mobility in today's market economy.

An essential aspect of studying the comprehensive problem of training future engineers is research related to finding optimal ways and means to improve the educational process, allowing at a high professional level to solve important problems related to the strategic direction of scientific and technological progress - computerization and operation of machines and equipment.

Solving such problems has led to the emergence of a large number of computer programs, which are increasingly used in the study of most subjects in higher education. Scientific and technical progress in social production and the introduction of information technologies in various spheres of life necessitates the training of specialists in engineering and technical specialties with established professional competencies. Therefore, the traditional system of training future engineers needs to be improved on the basis of modern advances in science and technology, optimization of forms, methods and tools of training using information technologies and CIT [8].

Analysis of recent researches and publications has shown that issues related to information technology in education have paid attention to V. Ivanov, A. Kalensky, I. Zakharova and others. Problems of computerization of education were studied by Y. Doroshenko, Y. Zhuk, Y. Mashbyts, O. Torubara, O. Yatsyuk and others. The use of modern computer hardware and software and improving the quality of education is shown in the works of F. Medvedev, K. Grebennikov, G. Kruchin, V. Sydorenko, N. Tverezovskaya and others. Issues of application of multimedia technologies in the educational process were studied by V. Bykov, Y. Zhukov, R. Gurevich, Y. Loboda and others. Almost all authors note that the use of information technology can increase the intensity and efficiency of the learning process; creates conditions for self-education and distance education, thus allowing the transition to continuing education; in combination with telecommunication technologies solves the problem of access to new sources of various information. However, the use of modern computer information programs and multimedia technologies in the training of future engineers is insufficiently represented in scientific materials.

Based on the generalization of the results of analysis of scientific sources, the study of practical experience of training engineers using CIT revealed the contradictions that objectively exist in the training process, namely [3]:

– between the level of training of future engineers and employer requirements in modern conditions market economy;

– between the number of national and foreign software products most suitable for solving engineering problems and the content, focus, technical level of higher education, which provides training for future engineers to apply these software products in practice.

In this regard, the article aims to analyze the features of the use in the educational process of future specialists in engineering specialties of information computer-integrated technologies, to provide recommendations for the use of software products and application packages in the study of engineering disciplines.

## 2. The use of computer-integrated technologies in the educational process for students of engineering specialties

Improving the professional training of future engineers is impossible without the use of new computer programs. They open up advanced opportunities for the development of computer (information) literacy, which affects the quality of competence of specialists in the use of modern information technology in educational and professional activities, knowledge of modern techniques and methods of using CIT in conducting various types of training sessions that are implemented in educational and extracurricular activities [4, p. 290].

Computer literacy is a component of professional competence, a necessary condition for the effectiveness of professional and pedagogical activities of lectures and future professionals in modern conditions. The future engineer must be able to use electronic resources to ensure the formation of basic skills in their engineering and technical activities in editorial and publishing systems, as well as to maintain a proper professional level [1, p. 23].

Information technology can be used as a powerful tool that encourages lectures to seek new non-traditional forms and methods of training and education of future professionals, developing his abilities. CIT are one of the forms of working with modern information technologies. They are based on the use of complex software systems and subsystems, are the basic critical technologies, i.e. technologies that underlie the creation of a wide range of knowledge-intensive products. The main principles of their development are complex automation, computer-integration, system integration, intellectualization, individualization, specialization, reengineering, technology transfer, and features: uniqueness of each implementation, multiplicity, diversity of systems and subsystems that are part of them, randomness and uncertainty processes (factors) operating in them, the vagueness of tasks, the unpredictability of consequences, etc.

The future professional character of the activity requires a combination of classical engineering education with in-depth mastery of computer technologies and special software. Note that over the past ten years, the principles of building technological systems have undergone significant changes. Traditional technological processes have been replaced by modern automated lines with microprocessor control devices and computer-integrated technologies. Therefore, the higher technical educational institution must provide training of highly qualified personnel who are familiar with the concept of computer-integrated industries and can implement it in industrial enterprises of Ukraine and the world. Given the features and specifics of computer-integrated technologies, we note that CIT in the process of training future engineers is a new generation of technologies that combine advanced information and industrial technologies, describe physical and mathematical models, study processes, and allow to manage the creation of the model, the process of calculation, processing and analysis of the obtained results.

CIT has an active influence on the process of teaching and educating students, as they change the scheme of knowledge transfer and teaching methods. At the same time, the introduction of CIT in the education system not only affects educational technologies but also introduces new ones into the educational process. They are associated with the use of computers and telecommunications, special equipment, software and hardware, information processing systems. They are also associated with the creation of new tools for learning and preserving knowledge, which includes electronic textbooks and multimedia; electronic libraries and archives, global and local educational networks; information retrieval and information reference systems [9].

The use of CIT tools should not become an end in itself, but should only be a tool for solving certain problems of learning, expanding and forming the thinking of future professionals to solve professional and educational problems.

In our opinion, creating a special environment, focused on the formation of professional competencies of the future engineer - one of the most advanced approaches to the introduction of modern CIT in the educational process.

Analysis of the situation in higher education institutions for the training of future engineers shows that the use of information technology and CIT significantly changes the role and functions of teachers and students, significantly affects all components of the educational process. The introduction of CIT into the educational process inevitably causes significant changes in the structure of the educational system of the higher technical institution.

The final goal of education of the future engineer is the inclusion of the individual in professional engineering activities. Therefore, according to the curriculum, the process of training future engineers begins with mastering the skills of working with modern computer technologies and the basic packages of applications.

The result is the acquisition of future engineers of certain skills in a graphic activity, namely in:

– rational and correct use of the capabilities of computer technology, in particular, in the use of graphics editors;

– fulfillment of algorithmic geometric constructions and creation of design documents;

– work with personal computers in geometric modeling of objects and processes, execution of various technical drawings.

Thus, disciplines from the cycle of natural science (basics of computer science and computer engineering, engineering and computer graphics) create conditions for in-depth mastery of fundamental engineering disciplines, but this course is not enough for the development of engineering thinking and professional competencies of future professionals. In the process of training specialists, there is a process of creating a theoretical foundation, accumulation of practical experience and professional methods of work. The use of the possibilities of new CIT tools in the educational process makes it possible to improve the process of forming the professional competencies of a specialist.

Drawing up the optimal structure of the educational process of future engineers is based on the integration of various scientific fields, interdisciplinary links and the principles of continuity in education. Ultimately, it is a combination of disciplines of the cycle of general training and the cycle of professional and practical training of future engineers, using information computer technology - COMPAS 3D, based on CAD (Computer-Aided Design) systems; because they are endowed with a high degree of clarity, form a spatial imagination and lead to an intuitive understanding of the essence of geometric transformations.

Computer-aided design means the development of a design project based on three-dimensional geometric modeling of parts, followed by the automated formation of a set of drawings and design documentation.

The thinking of a designer who uses 3D modeling is different from the thinking of a designer who only works with drawings. These differences are as follows:

1. The use of 3D modeling develops spatial thinking and facilitates faster decision-making.
2. Freedom in creating complex geometric shapes and understanding that these shapes can be easily implemented using integrated technologies, stimulate creativity, increase interest in work.
3. Organizing information about completed developments, leads to greater systematization of thinking.
4. The number of errors in the project decreases; the designer sees the result of his work in the design process.

The use of this program is accompanied by an increase in the individual work of students, which requires the constant support of the educational process by teachers. The important role of didactic goals: they are preserved as independent forms of organization of the educational process and at the same time are the elements of other forms of educational activities (lectures, practices, seminars, laboratory workshops).

Multimedia technologies allow using a computer to integrate processes and reproduce different types of signals, different environments, tools and methods of information exchange [2, p. 298]. It should be noted that scientists emphasize the ability of multimedia technologies not only to facilitate and make interesting the process of knowledge transfer but also to stimulate creative activity and independent human activity [5]. For the learning process to be effective during the creation of multimedia presentations, we adhere to the didactic principles of learning [6]:

– the principle of scientificity (presented information must meet modern requirements of science, be reliable);
– the principle of clarity (the design of a multimedia presentation should be aesthetically complete and descriptive);
– the principle of accessibility (the content of the presentation should correspond to the opportunities for students to learn);
– the principle of systematicity and consistency (presentation should be presented as an element of systematic learning following the curriculum of the discipline);
– the principle of connection with life (visual illustrations used in the creation of multimedia presentations must be modern and relevant);
– the principle of educational training (the content of presentations should solve not only the task of training but also education, for example, aesthetic).

The readiness of future engineers to use CIT can be defined as a state of mobilization, characterized by the presence in their minds of a holistic structure of the use of CIT in future professional activities and the motivation to implement it. The generalization of different approaches to understanding readiness allowed us to identify three interrelated components in its structure [4]:

– motivational and value (a set of motives, interests, needs and value orientations, the desire to independently set and achieve goals in professional activities, a set of ideas about themselves as a professional, the ability to think unconventionally and in different areas, integrating technological, mathematical and scientific knowledge to solve practical tasks);
– semantic (system of theoretical knowledge in the field of computer-integrated technologies, awareness of the importance of using these technologies in the preparation and further professional activity);
– operational (system of skills in the field of computer-integrated technologies, the ability to absorb the necessary information using various learning tools, the ability to independently organize their cognitive activities, the formation of which reflects the practical readiness of the future engineer to use computer programs).

Based on the theoretical analysis of scientific sources on the essence of computer-integrated technologies, the specifics of training future engineers and the study of practical experience, the scientific and pedagogical conditions for the use of CIT in the training of future engineers were determined. The most significant are:

– providing scientific and methodological support in the process of forming the readiness of future engineers to use computer-integrated technologies;
– awareness of future engineers of the importance of using e-learning tools as a resource of computer-integrated technologies;
– updating the independence of future engineers to create modern computer programs.

Scientific and methodological support should take into account the maximum use of the scientific potential of the university, i.e. the use of real opportunities that the university has for research and use of their results in the training process, as well as the support of each subject of the educational process to prepare future engineers for use computer-integrated technologies.

Regarding the awareness of future engineers of the importance of using e-learning tools as a resource of computer-integrated technologies, in our opinion, the use of e-learning tools can increase the level of training of future engineers through the formation of guidelines, interest, strong motivation, increased activity of students to use CIT in their professional activities. We interpret e-learning tools as software products that are created and worked with the use of computer and telecommunications equipment and provide creative and active acquisition by future engineers of knowledge, skills and abilities necessary for future professional activities [3].

Actualization of the independence of future engineers to create modern computer programs will be presented in the process of creating computer programs to perform cognitive and practical tasks. The presence of this quality determines the specific character of participation in professional activities. The future engineer, performing design and engineering production functions, must design applications and software interfaces for communication with engineering programs using object-oriented programming. Actualization of independence is provided by the ability to determine the purpose, the ability to systematize, plan, regulate, act consciously and proactively not only in acquainted circumstances but also in new conditions that require non-standard solutions.

We have proposed a method of forming the readiness of future engineers to use computer-integrated technologies; criteria, indicators and levels of readiness of future engineers for the use of CIT are defined; the results of the ascertaining and formative stages of the research are analyzed.

Three criteria for the readiness of future engineers to use CIT were identified:

– professional orientation with indicators (motivation of professional activity, satisfaction with the choice of profession; the need to achieve professional knowledge, skills and abilities; persistence in achieving their goals, the desire to succeed),

– cognitive with indicators (completeness of acquired professional knowledge; awareness of the use of computer-integrated technologies; the degree of skills to implement the acquired professional knowledge);

– technological with indicators (ability to use basic software packages and database management systems to solve problems of professional activity; ability to develop modern computer programs for communication with engineering programs using object-oriented programming; ability to design and structure computer networks, choose software, network topology and network hardware).

According to the criteria, four levels of readiness of future engineers to use CIT were determined: critical, basic, user and design [4].

The critical level of readiness of future engineers to use CIT is characterized by absence of motivation for professional activity; satisfaction with the choice of profession; low need to achieve professional knowledge, skills and abilities; absence of professional orientation; persistence in achieving their goals; absence of knowledge of the basics of computer science; principles of algorithmization, methods of numerical analysis, user skills, awareness of the use of computer-integrated technologies; absence of skills to apply basic software packages and database management systems; develop computer programs using object-oriented programming, design and structure computer networks.

The basic level of readiness of future engineers to use CIT is characterized by the presence of motivation for professional activity, the need to achieve professional knowledge, skills and abilities; insufficient professional orientation, persistence in achieving their goals; completeness of acquired professional knowledge; possession of skills for the implementation of professional knowledge; the desire to use CIT in future professional activities. Future engineers can apply basic software packages and database management systems, develop modern computer programs using object-oriented programming, perform numerical calculations, design and structure computer networks, choose software and hardware.

The user-level of readiness of future engineers to use CIT is characterized by a conscious motivation for professional activity, the need to achieve professional knowledge, skills and abilities; available professional orientation, persistence in achieving their goals; sufficient amount of acquired professional knowledge, the desire to use computer-integrated technologies. Future engineers have a strong ability to use basic application packages and database management systems to solve professional problems; develop modern computer programs for communication with engineering programs using object-oriented programming; set and solve optimization problems; design and structure computer networks, choose software and hardware, network topology and network hardware.

The design level of readiness of future engineers to use CIT is characterized by a strong motivation for professional activity; a conscious need to achieve professional knowledge, skills and abilities; expressed positive professional orientation, persistence in achieving their goals; the full amount of acquired professional knowledge; well-developed skills for the implementation of acquired knowledge; awareness of the use of computer-integrated technologies. Future engineers both in an acquainted field of activity and in unforeseen situations have the skills of a system design of engineering objects, methods of numerical analysis, understand the principles, structure and organization of automated integrated production, and can perform work in integrated software systems.

Based on the results of the research, a method of forming the readiness of future engineers to use CIT was developed. The stages of implementation of the proposed methodology were identified: initial-elementary, administrative-system and service-applied.

The initial-elementary stage was aimed at forming students' user skills (basic computer skills, peripherals, operating system, text editor, spreadsheet); knowledge of the basics of computer science (principles of algorithmization, fundamentals of formalization of logical processes and construction of programming languages, methods of numerical analysis, their program implementation).

The purpose of the administrative-system stage was the formation of skills to perform numerical calculations, to solve optimization problems; work with professional databases; know the architecture of computer systems, systems engineering integration and circuit technologies of computer systems.

At the service-applied stage, the students acquired theoretical knowledge, skills and abilities to work with appropriate software systems, have the principles of a system design of engineering objects, methods of numerical analysis in the professional field, understand the principles, structure and organization of automated integrated production, be able to perform work in integrated software systems.

Skills for developing training sessions in a new learning environment with the help of CIT play a key role in the successful professional activity of a future engineer. So, in our opinion, the introduction of CIT in the educational process of training specialists in engineering and technical specialties furtherer to:

– preparing students for the use of modern software in educational, research, professional activities;
– better mastering of educational material and its fuller comprehension;
– development of students' abstract thinking.

In addition, it allows you to use rationally learning time in the process of studying new material and allows to combine traditional and computer learning with the widespread use of computer-integrated technologies.

**3. Features of the introduction of computer-integrated technologies in the educational process of training specialists in higher education in the specialty 131 "Applied Mechanics"**

As noted, in modern society there are trends of constant growth of requirements for the professional level training of specialists in higher educational institutions of Ukraine following the modern needs of the world labor market. The engineering specialty "Applied Mechanics" is no exception.

Approval of the standard of higher education in the specialty 131 "Applied Mechanics" for different levels of higher education with details of general and professional competencies is an important factor in unifying the educational process in the global educational space and continuous improvement of national education.

However, a wide range of profiles of national and foreign machinery manufacturing enterprises and the rapid pace of creation of new generation industries, based on digital technologies in the sixth technological mode of design and production (global trend of implementation of programs "Industry 4.0" by Siemens and Chinese State Program "Chinese Production 2025"); as well as the limited terms of academic training in combination with new threats to human life through COVID complicates the possibility of in-depth study of certain professional practices according to the wishes of employers and students [7]. In addition, there is a need to use special hardware and software. For example, the introduction of additive technologies, which require special skills, is growing every year. Therefore, the structure of human resources needs to change, displacing the knowledge of computer engineering technologies.

Thus, we see the relevance of increasing the introduction of CIT in the educational process. In the market of educational services in Ukraine in this specialty, this approach is partially implemented in the following educational programs: "High-tech computer engineering", "Computer engineering in mechanics"; “Computer-aided design and machine design”, “Mechatronic systems engineering”, “Mechanical engineering technologies: computer-aided design systems”, “Computer-aided design and development of mechanical engineering technologies”, “Computer-aided design systems”, “Industrial engineering” [5]. Such groups of educational programs are aimed at implementing the concept of mechanical engineering technologies using computer-integrated technologies.

All other educational programs can be structured into the following groups:

1. Mechanical engineering technologies in general ("Mechanical engineering and equipment programming technology", "Engineering mechanics", "Applied mechanics", "Innovative technologies", "Mechanical engineering technologies").

2. Technologies for the production of special products ("Aircraft production technologies"; "Tool production: computer-forming technologies and tool design").

3. Welding technologies and related special processes ("Technologies and engineering in welding"; "Technological systems of engineering of joints and surfaces", "Welding", "Engineering of welding and related processes", "Technologies and equipment of welding", "Laser equipment and computerized processes of physical and technical processing of materials"; "Applied Mechanics", "Welding").

4. Design and engineering of machine-building products ("Dynamics and strength of machines"; "Tool systems of engineering design"; "Technologies of computer design of machines", "Engineering of packaging and packaging equipment", "Hydraulic machines, hydraulic drives and hydropneumatic"; "Dynamics, the strength of machines and vehicles”, “Metal-cutting machines and systems: computer design”).

5. Technologies of service of machinery manufacturing products ("Rehabilitation and increase of wear resistance of parts and structures", "Technical service", "Resource and energy-saving systems, devices and apparatus").

6. Technologies that implement certain methods of manufacturing machine parts ("Equipment and technology of foundry production") and processing of materials by pressure ("Applied mechanics of ductility of materials"; "Equipment and technology of plastic forming of mechanical structures").

7. Automated technologies in mechanical engineering (“Automated and robotic mechanical systems”; “Mechatronics and industrial robot machines”, “Computerized technologies and mechatronic systems in mechanical engineering”, “Computerized complexes of printing and packaging industries”).

Therefore, based on the analysis of national and foreign experience, we have identified the following ways to increase the efficiency of training of engineers in this specialty.

1. Limiting the time of teaching certain fundamental disciplines due to the widespread use of application software. In particular, in the discipline of "Higher Mathematics" no need to spend time studying the methods of solving integrals, differential equations, finding derivatives, etc. It is advisable to introduce an additional discipline "Computer Mathematics", which will cover high-performance methods of these calculations in the environment of software products of symbolic mathematics such as Wolfram Mathematica, Derive, Maple, MathCAD, etc.

2. We consider it expedient in the curricula of training specialists in the specialty 131 "Applied Mechanics" to provide for the study of such disciplines.

In the discipline "Engineering surfaces of machinery products", it is necessary to reveal the features of ensuring the quality of product surfaces at all stages of their life cycle (design of structures and technological processes of their manufacture, implementation of technical solutions in production, operation, rehabilitation and disposal). It is advisable to detail the study of technological methods of corrosion protection (methods of obtaining organic and inorganic coatings) and increase wear resistance during the long service life of products.

The discipline "Application Software Development Technologies" may include methods of creating application programs based on the use of programming languages (C ++, C #) and environments of specialized software products (software interface Solidworks API, LabVIEW, MATLAB, Wolfram Mathematica).

In the subject "Control systems of technological equipment», it would make sense to reveal the most widespread CNC systems, PLC systems, controllers of tracking drives, etc. It is obligatory to study CNC-systems Mach3, EMC2 (LinuxCNC), HeeksCNC.

The content of the disciplines "Theory of Mechanisms and Machines", "Resistance of Materials", "Details of Machines" should be combined into one discipline "Applied Mechanics". The presentation of the material should be based exclusively on the use of modern CAD/CAE-systems (SolidWorks Motion, OnShape, CATIA, NX-Unigraphics) [10].

Fundamentals of work and geometric modeling in CAD systems (Autodesk Inventor, SolidWorks, COMPAS, AutoCAD, ProENGINEER, Delcam, Solid Edge Free 2D Drafting CAD, Heeks CAD/CAM), the theory of projection and technical drawing should be taught in the subject "Geometric modeling”.

The teaching of the discipline “Recycling Technologies” is relevant due to the threatening trends of increasing environmental annoyances and the technological need to use secondary raw materials due to limited material resources.

Questions of technologies and equipment of machine-building productions, features of designing of workpieces and necessary attachments can be allocated in the whole list of separate disciplines: "Technologies of molding of metals and alloys", "Technologies of forming from polymeric materials of ceramics, glass and rubber", "Technologies of powder metallurgy", “Assembly technologies”, “Additive technologies”, “Welding technologies”, “Pressure processing technologies ”, “Material cutting technologies”.

Moreover, their volume may be characterized by a variable number of credits depending on the wishes of employers and students in each case. Thus, the strategy of flexible credit volume of disciplines at their fixed total volume is realized. Laboratory-practical session in the mentioned disciplines is recommended to be carried out with the use of modern technologies of virtual modeling in CAM-systems. For example, teaching the subject "Technology of casting metals and alloys" can be carried out using software products ProCAST, Magma, WinCast, CastCAE, LVMFlow, NX-Unigraphics and Polygon for modeling foundry technology. Similarly, in the discipline "Technology of manufacturing parts by pressure" a large number of technological operations can be modeled by software products DEFORM, QFORM, ANSYS/LS-DYNA, AutoForm, MSC.SUPERFORM, PAMSTAMP and others. Welded joints are conveniently designed in NX/Weld Assistant as part of the study of the discipline "Welding Technology". In addition, the software packages MPI/Flow, Moldflow Plastics Insight should be studied in the discipline "Technologies of forming from polymeric materials of ceramics, glass and rubber".

It is desirable to pay much attention to the study of specialized software products and individual modules of CAD/CAM/CAE-systems that implement automated calculations of machining allowances; cutting modes (CAD TP VERTICAL, EdgeCAM, SecoCut, Timeline, Techcard, T-FLEX Technology, Sprut TP, CARUS, SWR-technology, Impulse, Technologist-Gepard, Temp and KONCUT); technological rate making and design of technological documentation and selection of technological equipment (Timeline, Technologist-Gepard, NATTA, TEMP, T-FLEX Technology, AUTOMAT, ARBAT, CARUS, ADEM SARR, Metalink, Technomatix, Solumina, Notixia, Metamatrix and Proplanner), optimization of sheet metal cutting (Astra S-Nesting and T- Flex nesting), calculation of dimensional chains (GRACON 7 in the environment AutoCAD, Pro/ENGINEER (specialized module - CE/TOL SixSigina (CE/TOL)); SolidWorks with the TASys Works module; Autodesk Inventor, TECHCARD with the module CADMECH, Tolerance Stackup Validation in NX environment, eM-TolMate module in CATIA environment, etc.).

Computer product optimization (generative design in Solid Edge, Ansys environments), the study of principles and conservation and packaging technologies should be covered in the discipline of "Engineering Design".

It is important to conduct an environmental expert study of technical solutions using modern software products. An example is SOLIDWORKS, which allows you to perform the environmental examinations in real-time as part of the process of designing a new product. This product uses life cycle assessment criteria according to industry standards, allows you to quickly assess the environmental impact of a part, reduce material and energy consumption, and adhere to the development of environmentally harmful products.

Social, economic and scientific-technical effects should be determined using modern software products and online services in the presentation of the discipline "Efficiency of engineering solutions". A modern engineer needs knowledge, which is covered in the discipline "Bibliography and its use in modern search engines".

Students should be able to get acquainted with the structure and features of practical use of automation systems of engineering (design) data (PDM), planning and management of enterprise (ERP) and production (MES) when studying the discipline "PDM/ERP/MES - systems in machinery production".

Problematic questions of acquisition licensed software products can be solved by the wider activity of universities with the conclusion of agreements with international companies, the use of student and trial versions with limited functionality or period of use. This requires a clear structuring of the schedule and the order of presentation of the material. Each discipline can be characterized by a list of software products that can be used in the educational process. Since the universities train foreign students from around the world, the variability of these software products should be wide. However, the choice of specific software should be based on the results of monitoring its use in machinery enterprises in certain regions and countries of the world, as well as taking into account the wishes of foreign students. Therefore, during all types of internships (introductory, design and technological, etc.), the provision of information on the use of computer programs in enterprises of possible employment of foreign students should be an obligatory element of their reporting.

The creation of training courses in these disciplines and the implementation of these recommendations will lead to the in-depth study of educational material by saving time, structuring and increasing the productivity of students' learning material using computer-integrated technologies.

**Conclusions**

Thus, modern higher education is tightly coupled to the development of computer technology, information technologies and information systems in production. It is proved that the use of CIT in the training process of engineers is an objective process of forming the professional competencies of future specialists. The method of determination and ways to increase the readiness of future engineers to use CIT are proposed. Recommendations for the introduction of professional disciplines in the curriculum of future specialists in the specialty 131 "Applied Mechanics" with the use of CIT are given. The conducted researches do not exhaust all completeness of their coverage and do not claim to comprehensive disclosure of the specified problem. We see the prospect of further research in a deeper study of factors, consistent patterns, and features of the use of CIT in the training of specialists in engineering and technical specialties.

Further research should be aimed at creating educational and methodological complexes focused on the formation and development of the creative potential of students, the formation of skills to acquire knowledge, to carry out design, experimental researches and independent activities using computer-integrated technologies.

**References**

1. Bochar, I. (2011). Methodical aspects of preparation of engineering specialists for the use of ADOBE PHOTOSHOP CS5 in editorial and publishing systems. *Computer-integrated technologies: education, science, production, Proceedings of the Conference*. Lutsk, Ukraine.

2. Bykov, V. (2009). *Models of organizational systems of open education.* Kiev: Atika.

3. Danylchenko, L., Sipravska, M. (2020). Features of the educational process for foreign students with the purpose of effective using the components of the studing system. *Teaching and Learning of International Students in Ukraine. Challenges and Perspectives.* Preceeding of the V$^{th}$ International Scientific Conference. Ternopil, Ukraine.

4. Gurevich, R., Cademija, M. (2005). *Information and telecommunication technologies in the educational process and scientific researches.* Vinnitsa: Planer.

5. Radyk, D. (2020). Peculiarities of planning the educational process of higher education from foreign citizens on autumn and spring admission to study. *Teaching and Learning of International Students in Ukraine. Challenges and Perspectives*, Preceeding of the V$^{th}$ International Scientific Conference. Ternopil, Ukraine.

6. Stavyts'ka, I. (2015). Information and communication technologies in education. *Modern Trends in Teaching a Foreign Language for Professional Purposes in Higher Education*, Preceeding of the XI$^{st}$ International Scientific and Practical Conference. Kiev, Ukraine.

7. Vasylkiv, V., Dyachun, A. (2020). Improving the efficiency of training engineering personnel in the specialty "Applied Mechanics". *Teaching and Learning of International Students in Ukraine. Challenges and Perspectives,* Preceeding of the V$^{th}$ International Scientific Conference. Ternopil, Ukraine.

8. Zaharova, I. (2003). *Information technologies in education*. Kiev: Academy Publishing Center.

9. http://www.nbuv.gov.ua/e-journals/ITZN/em4/cjntent/07popeso

10. Abdullah, Z. (2020). Conventional milling into CNC machine tool remanufacturing: Sustainability modeling. *Economics, Management and Sustainability*, *5*(2), 39-65. doi:10.14254/jems.2020.5-2.3