Approaches, models, methods and means of training of future IT-specialists with the use of elements of dual education

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Abstract. The article substantiates the necessity and expediency of using the dual form of education in training specialists in the field of information technology in technical universities of Ukraine, interprets the concept of "dual education" from various sources, including UNESCO documents and the Law of Ukraine "On Education", analyzes some international experience of using dual study in higher education, in particular in Germany, considers the tasks to be solved for successful implementation of the dual form of higher education in Ukraine, and the main stages of this implementation for the period up to 2023. The paper considers some existing models of dual education that can be used in domestic universities. Also considered one of the approaches to the formation of methodological and information support for training of future specialists in information technology in the dual form of education based on distance learning support system developed on the basis of Moodle system, presented experience in implementing elements of dual education at the Faculty of Information Technology and Systems of Cherkasy State Technological University.

1. Introduction
The Ukrainian higher education gradually withdraws from the authoritarian pedagogy and implements democratic and humanistic values in the educational process. The nature of pedagogical relationships in education is fundamentally changing. The necessity of taking into account the age and individual characteristics of students, the development of their creative potential, abilities and talents, providing the best conditions for training and the future employment become of primary importance. Today higher educational institutions should strive to adapt to the students’ needs and be promptly responsive to the socio-cultural changes occurring in Ukraine and worldwide.

Thus, universities are in an active search for new educational approaches, shapes, technologies and techniques the use of which will provide an opportunity to reorient higher education to meet the most significant social, economic and educational needs and, at the same time, effectively apply numerous innovative, theoretical and methodical results that are accumulated in professional pedagogy over the last decade.

Lately many developed countries are actively implementing the dual model of training in higher education. The dual education model is understood as a model in which the entire process of mastering the profession comes in two establishments: vocational-theoretical parts of preparation are organized in the educational institution and the practical part takes place at some enterprise.

The dual form of higher education is especially relevant in the training of specialists in the field of information technology, which is changing and evolving so rapidly that the classical models of organization of higher technical education cannot meet the needs of employers – IT companies.
Today, the Ukrainian IT industry employs about 190 thousand highly qualified specialists. According to statistics, every year this number increases by 25-30 thousand specialists [13], while Ukrainian universities annually graduate only 12-16 thousand students of IT specialties. At the same time, the implementation of high-quality professional training of such specialists takes place in the conditions of dynamic development of the information and communication technology (ICT) industry, which necessitates continuous training throughout the professional activity of the specialist.

Within the conference “Synergy: Business and Universities” member companies of the Association “IT Ukraine” presented a unified list of requirements and recommendations for junior-level specialists [18]. Unfortunately, the analysis of these requirements and recommendations showed that they are aimed only at the current needs of the IT industry and do not require future professionals to have fundamental knowledge of information technology. Support parity between the current requirements of the IT industry for the training of future information technology professionals and their fundamental training, which is the basis not only of those software technologies that are relevant today, but also those ICT that will appear in the future, is the higher technical education task. Only fundamental technical education based on scientific bases of mathematics, computer science, engineering, modeling, forecasting, planning, theory and methods of optimization and decision making, artificial intelligence is a guarantee that domestic IT specialists will be in demand in the international and domestic labor markets not only today, but also in the future [27].

Therefore, the research of problems related to theoretical, methodological and practical tasks to the training of future IT professionals in technical universities in modern conditions is relevant.

According to the authors, it is the dual form of education that will help solve the problem of in-depth and effective cooperation between the university and IT employers.

2. What is dual education?
The term “dual education” is widely used as an umbrella term, referring to the fact that teaching and learning in vocational education and training (VET) is characterized by “duality” in two regards [23]:

- the duality of learning venues (schools/VET providers and training companies), sharing the responsibility of providing theoretical and practical training; and
- the duality of actors (public and private actors), sharing the responsibility for VET policy and practice.

The duality of the learning venues is the basis for the definitions used in European and international literature.

According to UNESCO, the “dual education system programmes” are called “programmes that combine school- or college- and work-based education”. Both components are substantial (i.e. go beyond a single internship or occasional class), although the work-based part usually occupies 50% of the programme time or more [28].

At the company, the apprentice receives practical training, which is supplemented by theoretical instruction at the vocational school. According to Cedefop, “dual education” concerns “education or training combining periods in an educational institution or training centre and in the workplace” [14]. Cedefop also refers to dual education as “alternance training”, underlining that the term “dual education” may be used interchangeably with “alternance training”, “apprenticeships” or “work-based learning”.

There are, however, some small but significant differences between these terms, as they differ with regard to the two aspects mentioned above.

The dual form of education means the education oriented on practice, built on the principles of social partnership of the university and the enterprise (organization, institution), aimed at the formation of a new model of training of students with the mandatory periods of production training and manufacturing practice, conducted on the basis of the enterprises (organizations, institutions) and provides for the strengthening ties with the production, the definition of the leading roles and increasing the responsibility of employers for the training quality [5].

The dual form of education is a method of education that provides a combination of training in educational institutions (in other subjects of educational activities) with training in the workplace in
enterprises, institutions and organizations for specific qualifications, as a rule, on the basis of the contract [29].

The purpose of this article is to analyse some approaches, models, methods and means of preparing future IT-specialists with the help of a dual form of training, as well as the experience of this form of study implementation at the Faculty of Information Technologies and Systems (FITIS) at Cherkasy State Technological University (ChSTU).

3. The international implementation experience of the dual education system

Due to their pedagogical and economic potential, apprenticeships and similar schemes are currently in the spotlight among both policymakers and researchers. The difficult situation of young people on the labour market today requires solutions that support school-to-work transition. A great deal of hope is placed in the development of apprenticeships and work-based learning more generally [23].

While all the member states (MSs) of the European Union (EU) have programmes that integrate work-based learning, their scale, popularity and outcomes vary greatly. There is no single model for apprenticeships, and apprenticeships are far from being a core track of VET in most MSs.

How can a country successfully move its young people from education to employment? What are the problems? Which interventions work? How can these be scaled up? These and other pertinent issues are addressed in the study commissioned by the EP: “Dual Education: a bridge over troubled waters?” [7].

The aim of this EU-wide study is to provide the EP Committee on Culture and Education with concise data on the state of play of vocational education and training in the Member States to serve as background information for ongoing and upcoming debates on the new generation of education and training programmes.

More specifically, the study addresses the following aspects:

- the main obstacles hampering the implementation of dual education in some MSs;
- why some MSs decide to implement/not to implement dual education systems;
- establishing links between excellence in VET, dual education and economic growth;
- identified trends and changes in dual education; and
- innovative approaches on how to foster and increase the attractiveness of this type of education.

The study explores the strengths and weaknesses of dual education/apprenticeships and explores policy developments within the context of countries own educational, social and economic characteristics. It also presents examples of good practice that may be of interest to countries looking to develop their vocational education and training offer.

Although alternance schemes across Europe are adjusted to the country VET system, four main types of VET pathways can be identified, concerning if and how work-place learning is embedded [7]:

- a fully-fledged apprenticeship system (Austria, Denmark, Germany and Switzerland);
- systems where apprenticeships are parallel to other VET tracks (Greece, France, Italy, Netherlands, Poland, England);
- school-based VET tracks with high shares of work-based learning (Finland, France, Netherlands);
- predominantly school-based VET systems/programmes (for example the Czech Republic, Slovakia).

For example, a schematic presentation of fully-fledged apprenticeships’ place in there of the education and training systems shown in figure 1.

The dual education form originated in Germany where it enjoys a wide popularity because it provides students with an excellent chance to obtain work experience while studying at the university [30]. Moreover, the company with which the student signs a contract pays for the tuition and also pays wages to the student during training. The dual training in Germany is regulated by the following legislative acts as [1]:

- Vocational Training Act (Das Berufsbildungsgesetz (BBiG));
• Promotion of Professional Training Act (Das Berufsbildungsförderungsgesetz (BerBiFG));
• Young Persons Employment Act (Das Jugendarbeitsschutzgesetz (JArbSchG));
• Handicrafts Code (Die Handwerksordnung (HWO)).

Figure 1. Schematic presentation of fully fledged apprenticeships’ place in the rest of the education and training system ([7], p. 102).

The programs of the dual training are offered in a variety of technical and economical directions. After three or four years of study the student receives a Bachelor's degree (B.A., B. Sc., B. Eng.) and can get a permanent position at the company.

Therefore, the graduates of the programs have not only a valuable practical experience, obtained during their training, but also a further place of employment.

Many companies in Germany offer employment within dual training. The choice of companies ranges from small and medium sized enterprises to large international corporations like IBM, SAP, Daimler, Siemens, Volkswagen, etc.

Each university with dual training programs has a list of partners it cooperates with. Applying for the dual training is similar to the job search. The student must independently establish the contact with the important for him companies and send them the application. As a rule, the candidate must produce the following list of required documents:

• a cover letter;
• curriculum vitae (CV);
• statement of estimates;
• a language certificate that validates the knowledge of German (and/or English);
• additional certificates suitable for the filed application (confirmation of practical work experience, participation in projects, seminars, etc.).
Some problems with the introduction of the dual forms of training emerge in the sectors of the economy with low wages. Depending on the area and scope of activities from time to time there is a lack of volunteers to get dual training or the parties concerned on the part of employers.

A striking example of the implementation of the classical dual education system in Germany is the Duale Hochschule Gera-Eisenach (DHGE) – Gera-Eisenach University of Applied Sciences [12]. DHGE is a state higher education institution specializing in dual practical training programs. In cooperation with companies and institutions, DHGE provides a large number of accredited bachelor's programs in business, social sciences and technology, including ICT.

Interesting experiences with the introduction of dual training system exists on Philippines [2].

4. The tasks for the implementation of the dual forms of higher education in Ukraine
Taking into account the relevance and sustainability of the dual forms of higher education, the Government of Ukraine on September 19, 2018 approved the Concept of training specialists in the dual form of education [5], which aims to develop the principles of the State policy for improving the training quality of specialists on the basis of the dual educational forms.

This Concept is supposed to establish an equal partnership of institutions of higher, professional pre-higher, vocational (professional) education, employers and all those who study with the aim of acquiring the experience of practical application of the competencies and their adaptation in the conditions of a real professional activity. The developed concept uses the German experience of the dual educational forms, presented through the representative office of the Friedrich Ebert Foundation, a German-Ukrainian agropolitical dialogue, the Eastern Partnership Project “Dual education in the dialogue” with the participation of educational institutions of different levels, the Federation of employers of Ukraine and was used by the Working Group established by the Ministry of Education and Science of Ukraine.

Ministry of Education of Ukraine made an indicative timeline for the implementation of the dual form in full as a part of the Concept which envisages the following main stages [5]:

- Stage I. Development of normative-legal base for the introduction of dual education in full (2018);
- Stage II. Development of standard models of the dual form of education in institutions of higher education, vocational and professional pre-college education. Piloting of models. Efficiency assessment (2019-2020);
- Stage III. The creation of dual education clusters on the basis of wealthy educational institutions and interested business entities (2020-2023).

For the distribution of dual forms of higher education in Ukraine the following tasks must be solved:

- to study the experience of innovative development of higher school in Germany, which is of interest to such innovations as: the integration of science and education, social partnership, training in the enterprise;
- to summarize the advanced foreign and domestic experience of formation and development of dual forms of higher education;
- in each industry to clearly define the list of specialties which can apply the dual form of higher education;
- to assess the state of higher education in Ukraine and the possibility of diversification of the educational system and the phased introduction of elements of dual education in preparing future professionals;
- to define the core list of companies willing to become partners for the implementation of dual forms of higher education and to develop common rules of cooperation of universities with these businesses;
- universities together with enterprises need to develop recommendations for the implementation of elements of the dual form of higher education;
- to ensure the establishment or selection of training classrooms, landfills and laboratories for training in the dual form of education at the enterprises;
• to conclude contracts with the enterprises to ensure production practices at their bases;
• to introduce a mandatory (once a year) training of teachers of vocational-oriented disciplines in courses, or at the leading enterprises of the relevant industry;
• to prepare scientific and pedagogical staff for the organization and teaching methods in the framework of the dual form of higher education.

If the above mentioned conditions are fulfilled, the introduction of dual forms of higher education could solve many existing problems in the field of education in Ukraine.

The purpose of this implementation is to overcome disparities between the supply of educational services by the university and the needs of employers in terms of the structure of the educational process, the content and scope of curricula and programs, quality of students' preparation, provide a mobile response to changes in production technology and modernization of the content of higher education, given the requirements of the relevant enterprises (organizations, institutions) in the organization of the education process.

Some Ukrainian universities have already introduced elements of a dual education system. Among them is the National Technical University of Ukraine “Kyiv Polytechnic Institute named after Igor Sikorsky”, in which the master's program of dual education “Dynamics and strength of machines” received a certificate of European accreditation. The dual education provided by this program gives students the opportunity not only to study theory in classrooms, but also to gain practical skills on the basis of “Progresstech-Ukraine” and “Boeing-Ukraine”, where students of the program are already their full-time employees. The master's program “Dynamics and Strength of Machines” trains mechanical engineers and researchers whose knowledge is required in the aerospace industry, nuclear energy and more. The program benefits of the European accreditation giving the diploma greater value to employers, and therefore graduates of the program will have a competitive advantage in employment in foreign companies [22].

Since 2016, the National Technical University “Kharkiv Polytechnic Institute” has a training program in the dual form of education. Under this program, students have the opportunity to legally combine training and work – to obtain the necessary theoretical and practical knowledge in the company in the field of study. As a pilot project of the dual form of education, the training of masters at the Department of Software Engineering and Information Technology of Management was started, according to which in 2017-2018 there were 66 students majoring in 121 “Software engineering” and 122 “Computer science” with practical experience in projects of various IT companies [25].

In the pedagogical field, the need to improve the training system of modern highly qualified teachers and ensure the successful adaptation of graduate students to their professional activities are no less acute than in the industrial sphere. To this end, the National Pedagogical University named after M.P. Drahomanov on the basis of the Faculty of Computer Science concluded agreements on the pilot implementation of a dual system of education during the training of masters of informatics to cooperate with lyceums, gymnasiums, high schools, where students already work in full-time positions as computer science teachers [20].

5. Model of the dual form of education in higher school
The introduction of elements of dual education in higher schools is based on the combination of vocational theoretical and vocational practical training in the educational process in the proportion of 30% (40%) of theoretical lessons and 70% (60%) of practical classes (or the proportion of learning at the enterprise 25% to 50% credits). Industrial training and industrial practice are carried out directly in production using a material-technical base and human resource of the enterprise (organization, institution), it provides students with the opportunity to simultaneously study at the university and to master the basics of a chosen profession directly at the enterprise.

In contrast to this scheme, the standard of dual education system of Germany is more business-like because it is interrelated (figure 2) [19]. Thus, there is a further evolution: the employer not only pays for training and employs the students but also provides an educational process. Practical knowledge and skills (75-80% of the total training time) are created at the enterprise. The educational institution creates
conditions for the formation of the necessary theoretical knowledge and basic practical skills (20–25% of the time).

The relationship between the employer and the student are governed by the contract between the employer and the higher educational institution that is by the professional standard. Educational standards of the professions are the prerogative of the Federal Institute of Vocational Education of Germany. The institute includes an equal number of participants and an equal number of votes in three groups: employers, trade unions and public authorities. They work together to develop educational standards approved by the Ministry of Economy of Germany but not by the Ministry of Education.

Thus, all components of the educational process in the dual form are located in the same area and the methodological support is the responsibility solely of institutions of higher education.

The authors of this research [19] suggest on the basis of the relations: “the institution of higher education” – “enterprise” – “training center” – “student” to create a unified educational field of dual forms of higher education (figure 3).

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**Figure 2.** Scheme of German dual education system [19].

**Figure 3.** The scheme of the unified educational space of dual training forms: “institution of higher education” – “enterprise” – “teaching center” – “a student” [19].
Each of the participants makes a contribution to the creation of this educational area: the educational institution provides the theoretical training, the company reinforces its practice, a training center (TC) on behalf of the Ministry of Education and Science develops a complete method of training in the dual form. The student, who studies on this basis, rises to a qualitatively new level, based on the interaction with teachers, the employer and a coordinator.

Institutions of higher education, the company and TC are the basis of the educational pyramid atop of which is the student. Projection of the educational area on this field is the professional standard. It is clearly seen that it should be developed jointly by all members of the triad. This confirms the thesis that the dual form of higher education is an association of interests on a parity basis of business, a young man and the State. From this point of view the professional standards form the educational area. It is presented in the dialectical unity and interaction of the educational area and the professional standard. They mutually develop each other resulting in the improvement of educational services. This should facilitate the harmonious combination of the main elements of higher education.

Projection of the educational area from the company on the plane “the institution of higher education” – “TC” – “a student” is a set of general and professional competences acquired by the student in the learning process.

Projection of the educational area on the plane “enterprise” – “TC” – “a student” by the institution of higher education provides a fundamental and professionally-oriented theoretical basis, which has to be mastered by a student.

Projection of the educational area from the TC on a plane “institution of higher education” – “enterprise” – “a student” provides a complex of training materials on the organization of the dual form of higher education, which should be provided at the enterprise and in the institution of higher education.

Based on the mentioned above it can be concluded that any bias in one direction or another immediately reveals the incompetence of the relevant side of the process, thus the system becomes self-regulating. The feedback between all parties makes the system flexible which makes it possible to take into account any changes in education and in business (industrial sector).

The model of a single educational space of the dual form of higher education for students can be applied in the universities of Ukraine.

6. Methodical and information provision of the dual forms of higher education in ChSTU

The environment of a person has the greatest impact on his/her formation and development. So, today an important and topical issue for the university is creating such a high-tech information-communication educational environment where a student studies during the entire period at the higher technical school.

The priorities in building an information and educational environment should be: widespread use of computer-based tools and ICT learning in the educational process, practical implementation of distance learning technologies, providing ICT support for research, widespread implementation of ICT in education management at different levels, in different industries, for all types of educational institutions [3].

The information and educational environment should be formed on new technologies and provide the educational process with electronic textbooks, electronic teaching and methodological complexes on relevant subjects, list and guidelines for the use of various web and cloud services, broadband Internet, and create conditions for the introduction of pedagogically balanced teaching models; use of cloud and mobile-oriented learning environments for the formation of key competencies and life skills of students; use of various virtual and research laboratories; reveal the personal abilities of students, monitoring personal and academic achievements; take into account the own needs of informatization of each educational institution [4].

An example of such an information and educational environment is the environment created at Ternopil Volodymyr Hnatiuk National Pedagogical University (see, for example, [26], where private and public cloud technologies are integrated into the university’s academic cloud to support the implementation of group methodology in the educational process.
An important component of the information and educational environment, where students can access learning materials anytime and anywhere, is a Support System of Distance Learning (SSDL) that is a multifunctional, modular, multimedia hardware and software system to support distance learning of students, built using network and web technologies [16].

SSDL as an essential component of information and communication educational environment of a University should include the following subsystems: the subsystem of user management, messages subsystem, subsystem of access to the distance learning courses, testing subsystem, subsystem of students' learning outcomes, subsystem of distance learning courses management.

The authors offer to create a system of methodological and information support of dual forms of training of future specialists in information technology on the basis of SSDL. SSDL must not only provide a student with an access to educational materials and provide a remote communication with the teacher so that he could ask questions, to quickly get comments and communicate with other students studying the same course.

The efficiency of the SSDL use is determined by the input, editing and layout of educational material, including modern multimedia and hypertext, tools for creating exercises and tests, convenience of the interface for a user, etc., which in the conditions of Informatization of educational process become a means to provide new educational services and access to electronic educational resources (EER) in any place with the Internet access.

SSDL of ChSTU [8] and SSDL of FITIS [9] placed on the web server of the University are based on the Moodle [21] system of ChSTU. The choice of Moodle system is due to the availability of convenient content development tools, management subsystems for the educational process, SCORM support, the localization on the Ukrainian language, modularity, multimedia, open-source code that provides it with the highest popularity ratings in most countries of the world [6], as a platform for distance learning.

One of the components of the didactic provision of the educational process of the future computer science bachelors are e-learning courses in certain disciplines or the disciplines placed in SSDL.

E-learning course (ELC) is an electronic educational resource as a set of teaching materials in an electronic form and educational services for individual and group learning using distance learning technologies [17].

The particularity of ELC use in comparison with other electronic educational resources is that ELC is designed for an independent and systematic mastering of educational materials under the guidance of a teacher during the studies.

In the process of teaching ELC constantly changes and improves both by the teachers of the course and by the students themselves, in particular through the use of Wiki technology, the creation of a course glossary.

As a rule, several distance learning technologies are used in the electronic training course. The teacher should be guided by the following principle: if the didactic task can be implemented through the use of more simple technologies, preference should be given to them.

Table 1 shows the list of psychological and pedagogical technologies that might be used in a distant and dual training of future bachelors in computer sciences and Moodle system tools [17].

The educational content of ELC are the course resources that is informational, educational, methodical and other materials in the text form, in the form of HTML pages, hyperlinks, presentations created in SSDL or loaded into it. The content of the training course is shown on the basis of these materials.

ELC contains the materials of the practical training of students on the course and tasks for independent preparation of students. Training materials for laboratory and practical works are provided with all necessary concepts and definitions, mathematical formulas, the necessary examples of how to perform certain tasks and control questions.

Online tutorials, guides and manuals posted to ELC, are educational resources that provide the opportunity to apply the basic volume of the studied material, independent work which contributes to deeper learning and understanding.
Table 1. Pedagogical technologies and means of Moodle to implement them.

| Pedagogical technologies                                      | Tools of pedagogical technologies implementation in the system Moodle |
|---------------------------------------------------------------|-----------------------------------------------------------------------|
| Technology of problem study                                   | Lesson, Workshop, External tool                                        |
| Cooperative learning technologies                             | Lesson, Workshop, Feedback                                             |
| “Brainstorming” method                                        | Chat, Forum                                                            |
| Method of projects                                            | Assignment, Workshop, External tool                                   |
| Even training:                                                | Workshop                                                              |
| • review                                                      | Internal mailing list of messages                                    |
| • pal friends                                                 |                                                                      |
| Collective training:                                          | Workshop                                                              |
| • report (presentation)                                      |                                                                      |
| • discussion                                                  | Forum                                                                 |
| Training in cooperation:                                      |                                                                      |
| • training in small groups                                    | Mode “Grouping”                                                       |

Manuals designed so that students could move from the activity carried out under the guidance of the teacher, to the activities organized by the students themselves independently with the ability to exercise self-control. This is why they contain a detailed description of rational methods and activities and recommendations for their effective use.

ELC realizes the possibility of automated control of students' knowledge: input, current, modular, rating, final and deferred carried out, usually in the form of a computer test Bank with test questions at different levels of complexity.

In modern conditions the learning outcomes of students of higher education are determined by the level of completeness of their general and professional competencies. Therefore, in terms of distance and dual training an important issue is the availability of technologies that would provide the opportunity to monitor the process of formation of students competencies and evaluation of their development level. Moodle system, starting with version 2.7.9, includes the module of users' competencies control (figure 4).

The basis of the tool is the concept of competencies accumulation:

- each student at the beginning of the study course is characterized by a set of already formed competencies;
- each course specifies the list of input methods which are necessary for the student of the course and a list of basic competencies that must be formed by the student after successful completion of the course;
- after specifying the target set of competencies a student receives a recommended set of study materials and tasks as well as his own path of course from the system.

The student can see current and target competencies in his personal account. They are available for the teacher through each user's profile. The system calculates the development level of each competency on the basis of the final grade for the course and the necessary time for this.

The functional of learning trajectories management according to the competencies in the Moodle system provides the ability to organize adaptive learning. It can be used for the independent preparation for exams, for certification and re-training of specialists, for organization of remote and dual training and continuous education.

In addition to the facilities provided by SSDL for the organization of blended learning, the university needs to provide online communication of teachers, students and employers during internships, or students' stay in IT companies during practical training in a dual form. Web-based video conferencing tools are used to provide such communication and feedback when staying out of university, in particular: Skype, Zoom, Cisco WebEx, Google Class, Google Meet, Big Blue Button, Microsoft Teams, etc., as well as mobile tools (Viber, Telegram, Messenger, etc.). These tools allow teachers to organize audio,
video, and web conferencing, use features such as online meeting scheduling, note-taking, screen sharing, recording and instant messaging between participants.

Figure 4. The configuration window of the competencies in the Moodle.

7. **Experience of implementing elements of the dual forms of higher education in ChSTU**

   In today's information society there is a great demand for competent professionals in the field of information technologies, able to apply existing technologies to solve problems in various spheres of social production, to maintain and adapt them to practical needs and to be ready to accept new solutions and develop technologies of the future.

   Training of such specialists is based on the dynamic development of the industry of information communication technology, underlining the need for continuous learning throughout professional activity. In these circumstances the relevant issue is the problem of professional training of future specialists in the field of information technology.

   Therefore, the dual form of higher education is especially relevant when training for the information technology industry that is so rapidly changing and developing that the classical model of education organization of the higher technical school cannot meet the needs of employers – IT companies.

   The dual form of training requires even more in-depth cooperation between the university and employers. If the student participated in production only during the summer and winter practices, term papers and dissertations or projects, now the modern world requires a more in-depth synergy in teaching students beginning from the first year of study.

   Four years ago at the Faculty of Information Technologies and Systems ChSTU the emphasis was placed on cooperation and collaboration with leading IT companies, in particular, on retraining of teachers and on attracting of practical teachers to the teaching process. Two years ago own volunteer project of the additional professional education for students and the dual degree program with Polish universities for future masters of information technology was introduced.
In 2016-2017 academic year the FITIS team focused attention on the experiment on the introduction of elements of dual forms of higher education and on creation of the environment for the students that will help them develop and promote their own IT projects.

Before the experiment the FITIS students were surveyed regarding their employment in the periods of 2016-2017 and 2017-2018 and in the context of specialties (figure 5, 6).

**Figure 5.** Employment Diagram of FITIS students in 2016-2017.

*Note: Designations used in Figure 7 and Figure 8: CS – computer science; SA – system analysis; ITD – information technology design; SCS – specialized computer systems; CN – computer networks; SP – system programming; ISM – information security management; SE – software engineering.*

**Figure 6.** Employment Diagram of FITIS students in 2017-2018.
From the above data on the graph (figure 7) it can be seen that already during the third year of study a significant proportion of students works and on the 4th and 5th courses this figure increases every year. The increase of working students is due to the fact that the practical training takes place directly in IT companies or with their support, as well as through the introduction of elements of dual training.

![Summary data on the proportion of working students of FITIS](image)

**Figure 7.** Summary data on the proportion of working students of FITIS.

The basic principle of dual education for future specialists in information technology is that the theoretical part will be learnt at the university and the practical part will be learnt at the enterprise, that is, lectures on professionally-oriented disciplines must be organized in the university classrooms, practical and laboratory classes in these disciplines – in the IT company or IT-department of the enterprise.

According to a survey among students of 1st-4th years of the FITIS ChSTU (about 500 respondents), the majority of them would like to visit enterprises in the framework of dual forms of training, starting with the second year (43.8%) and first year (34.4%), (figure 8), citing the opportunity to work on real projects and learn using innovative techniques under the guidance of leading practitioners. But the least number of respondents would like to visit enterprises in the framework of dual training forms, starting with the third year of study (18.7%) and fourth year of study (3.1%), that is, the majority of students believe that it is too late to start the dual education during the third and fourth years of study.

![A chart survey of students in the dual form of training](image)

**Figure 8.** A chart survey of students in the dual form of training.
The introduction of elements of dual forms of higher education at the Faculty of Information Technologies and Systems provides the organization of learning in professionally-oriented disciplines, programs and participation of specialists (mentors) of IT companies, training of students with representatives of companies-manufacturers of hardware and software during production practices and extracurricular time with a view to their preparation for professional certifications from different areas of it, specifically in software testing (for the Ukrainian HI-Tech Initiative and QATestLab) [24], management information systems, configuration and maintenance of network equipment and cloud technologies (according to CISCO Networking Academy program) [10].

During September-December the students of specialty 121 “Software Engineering”, 122 “Computer Science” and 124 “System Analysis” took the course “Technology of software testing” at the University provided by IT company QATestLab in the framework of the cooperation agreement using appropriate teaching materials [15]. The course covered the main topics in software testing (testing techniques, test-design, test plans, preparation of report on testing results), working with bug-tracking systems, check-lists. The most interesting topics for students were related to mobile testing and game testing. All tasks were performed on the learning platform QATestLab and with the local access to their software. After each block of tasks students had to upload the reports on the performance of their work. All the obtained points the students could check on the company's website in their own cabinet. After a successful completion of the course, students had the opportunity to obtain appropriate certificates.

At the Centre of Health Information Systems of ChSTU, which operates under the Department of Computer Science and System Analysis (DCSSA), extracurricular training was provided for undergraduate and graduate students for certification in the administration of the medical information system “Doctor Eleks”, with the participation of specialists of the company “Doctor Eleks” (Lviv, Ukraine) [11], which is the developer of the medical system and the representatives of the DCSSA. The learning outcome was the successful delivery of audience certification exam, awarding them with the relevant document.

In agreement with IT partners of ChSTU some FITIS students of different courses, including specialties 122 “Computer science” and 124 “System analysis”, did an internship in IT companies “Master of Code Global”, “SPD-Ukraine”, “InterLink”, “Andersen” and “Triumph IT”.

The faculty has introduced the practice of forming project groups of students of different IT specialties and years to implement real projects during their studies. Although this is a voluntary and additional workload for students and teachers, project teams are still popular. Faculty teachers and professional mentors from IT companies, who are needed for these projects, constantly work with project groups.

The most powerful at the faculty now is the “Dean Office” project, in which students gain the knowledge and skills expected of them in IT companies.

The "Dean Office" project aims the development of a web-based software system working with the dean's offices and student learning activities information. The project started in November 2017 as a “Project Workshop on Programming”, and is now implemented as part of research work of the Department of Computer Science and System Analysis (CS and SA) “Development of information and analytical system to support educational activities of university structural units” (#110118U002315) [31] under mentoring of three Cherkasy IT companies: Master of Code, SPD-Ukraine and InterLink.

Representatives of local IT teams advise students and motivate them to work. Representatives of IT companies note that the main advantage of the project is that inside university the students can work as real developers of software products using a stack of modern technologies. Because as soon as they are employed with an IT company, they are already expected to have that experience. By participating in such a project, students have the opportunity to consult with the supervisor and mentors from IT companies that communicate closely with them. Participation in such joint educational projects is an investment in the future by both students and IT businesses. While studying and participating in the project, students have good training and enter the IT market with a set of knowledge and skills necessary for a successful start of their career in IT companies. About 25 students of the faculty have already got such training within the project, most of them are employed in IT companies – the partners of the project.
Another element of dual education can be considered the participation of students of computer specialties in research and technological contracts of departments with IT companies for software development and implementation in enterprises where the informatization of production and management processes is made.

Thus, since 2016, CS and SA Department has performed four contracts for technological work to adapt and implement medical information systems in health care facilities in Cherkasy and Cherkasy region. More than 20 students of 3-4 courses and master's students took part in the implementation of these contracts. As a result of this work, a significant number of graduates were employed as software engineers in medical institutions, and 8 masters became employees of Triumph IT LLC as a computer systems analyst.

In general, this approach is in line with the concept of introducing dual education in Ukraine and gives FITIS students confidence in their professional future, because they see the results of their own developments in real IT companies. Students are more consciously beginning to relate to the formation of their individual educational trajectory, in particular when choosing the elective disciplines necessary for their own development, which is 25% of the disciplines of the curriculum of each specialty. In addition, students actively use the opportunity to study in vocational-oriented courses, trainings and webinars within the non-formal education offered by IT companies, and the faculty always supports them and creates favorable conditions.

8. Conclusion
The study on the implementation of the dual model of training in higher education at the university on the example of IT showed that the majority of companies willingly agreed to cooperate, if there were a wider variation of the terms of the agreement on cooperation between the enterprise and the institution of higher education.

It is impossible to fully organize the practical part of dual training due to the production particularities of some enterprises and due to the reason that the manufacturing processes or material base make it impossible to work out all the required competencies, necessary for the students in accordance with their specialty. In certain cases some of the competencies require admission of students to work on expensive equipment which is available only for experienced professionals, but an attempt to train students to work with it can result in significant material damage to the enterprise. Some businesses are willing to accept for training only a small number of students. All this must be considered when concluding agreements on cooperation between higher education institutions and enterprises in the framework of the dual form of higher education, in particular in the preparation of future specialists in information technology.

We hope that the first experience of introduction of dual forms of higher education in FITIS will give positive results and the computer science graduates will become more competitive in the IT market and innovative approaches in organization of educational process will find wide application in the university; therefore it will be interesting and useful for both present and future students.

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