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Technology Education in Ukraine

Social changes and processes that take place in Ukraine are related to its affiliation to the European educational space. One of the conditions for successful integration is a presence of such characteristics as: competence, creativity, professionalism, and humanity in the activity of social subjects of all spheres of life. An outstanding role in this process belongs to the establishments of higher education, whose task includes the training of highly skilled professionals, capable of working in the conditions of globalization, standardization of European education, informatization, and rivalry.

Ukraine has a multi-stage education system. The training of junior bachelors, bachelors, masters, Doctors of Philosophy, Doctors of Science is carried out according to education and qualification levels (fig. 1). Under the Law "On higher education" (2014), there are such types of higher educational establishments in Ukraine as: universities, academies, institutes and colleges.
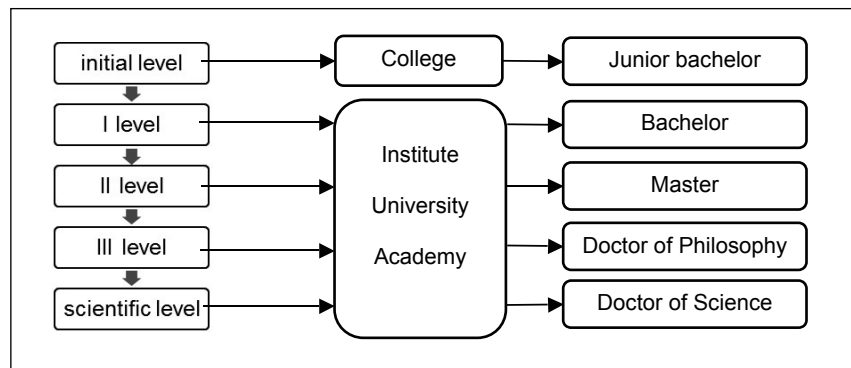

Figure 1:   Structure of multi-stage higher education in Ukraine

The initial level (short cycle) of higher education corresponds to the fifth qualification level of the National Qualifications Framework and includes the person's obtainment of common cultural and professionally-oriented training, special skills and knowledge, certain experience of their practical ap-

plication with the purpose of implementing the typical tasks which are required for primary positions in corresponding occupational categories.

The first (bachelor) level of higher education corresponds to the sixth qualification level of a National Qualifications Framework and includes the person's obtainment of theoretical knowledge and practical skills and abilities, sufficient for successful implementation of professional duties within a selected speciality.

The second (master) level of higher education corresponds to the seventh qualification level of a National Qualifications Framework and includes the person's obtainment of deep theoretical and / or practical knowledge, skills, abilities in a selected specialty (or specialization), a common basis of methodology of scientific activities and / or professional activities and other competencies sufficient for the effective implementation of innovative tasks of a corresponding level of professional activities.

The third (educational and scientific) level of higher education corresponds to the eighth qualification level of the National Qualifications Framework and includes the person's obtainment of theoretical knowledge, skills, abilities and other competencies sufficient for producing new ideas, resolving systemic problems in professional and / or exploratory and innovative activities, mastering the methodology of scientific and teaching activities, undertaking a study the results of which have scientific novelty as well as theoretical and practical value.

The scientific level of higher education corresponds to the ninth qualification level of the National Qualifications Framework and implies acquisition of competencies in working out and introducing teaching techniques and methodology for research papers, the creation of new systemically important knowledge and / or progressive technologies, and the settlement of scientific challenges or applied problems, which are of nation-wide or universal importance.

In Ukraine teacher training and technology, preparation is underway according to the *governing documents*: standard for higher education, educational (educational and professional or educational and scientific) program. At each level of higher education, education acquirement involves a person's successful implementation of a specific program, which is a basis for awarding a specific degree of higher education.

1. *Junior bachelor* – is an educational and professional degree, which is received at the initial level (short cycle) of higher education and conferred by a higher educational establishment as a result of a candidate's success-

ful implementation of an educational and professional program the scope of which equals 90 – 120 credits ECTS. A person has a right to receive a junior bachelor's degree provided that he / she has a full general secondary education.

2. *Bachelor* – is an educational degree, which is received at the first level of higher education, the scope of educational and professional program equals 180 – 240 credits ECTS. A person has a right to receive a bachelor's degree provided that he / she has a full general secondary education.

3. *Master* – is an educational degree, which is received at the second level of higher education for the educational and professional or the educational and scientific program. The scope of a master's educational and professional training equals 90 – 120 credits ECTS, the scope of educational and scientific program – 120 credits ECTS. The educational and scientific program of master's degree includes a research (scientific) component, the volume of which equals at least 30%. A person has a right to receive a master's degree provided that he / she has a bachelor's degree.

In Ukraine, prior to 2014 under the law "On higher education" (2002), there was a specialist training (educational and qualification level of higher education of a person who has obtained a complete higher education).

4. *Doctor of Philosophy* – is an educational and simultaneously the first academic degree which is received at the third level of higher education on the basis of a master's degree. A Ph.D. is conferred by a specialized board of studies of a higher educational establishment or by an academic institution as a result of a candidate's successful implementation of a corresponding educational and scientific program and a public thesis defense before a specialized board of stu A standard term of a Ph.D.'s training in a postgraduate department (mili adjunct department) is four years. The level of educational contents of the educational and scientific program of a Ph.D.'s training equals 30–60 credits ETCS.

In Ukraine, prior to 2014 under the law "On higher education" (2002), there was a training of Candidates of Sciences. Since the law "On higher education" (2014) came into force, the academic degree of Candidate of Sciences has equaled the academic degree of a Doctor of Philosophy (Law of Ukraine on higher education № 2984-III, 2002).

5. *Doctor of Science* – is the second academic degree which is received by a person at the scientific level of higher education on the basis of a Ph.D. and encompasses the obtainment of the highest competencies in the scope of development and implementation of research work methodology, un-

dertaking of original studies, achievement of scientific results, which bring about the settlement of important conceptual and applied problems and are of nationwide or worldwide importance and published in scientific publications (Master's Education and Qualification Description, 2012).

In Ukrainian pedagogical science a lot of innovations were provided that focused on the improvement of students' technological training and that includes appropriate pedagogical personnel training. At the present time, technology teachers' training is used in such knowledge areas as 01 – "Education" in specialties 014 "Secondary education" (in subject specializations) and 015 – "Vocational education" (in specializations) (On approval of the list of disciplines and specialties, used for training applicants who get higher education: resolution № 266, 2015). We offer the analysis of a state order and number of applicants, who entered a specialty 014 "Secondary education" (table 1) (Entrance campaign, 2015) and 015 "Vocational education" in 2015 (table 2) (Entrance campaign, 2015).

Table 1: Ratio of license volume, volume of state order, number of applicants, admitted to a specialty 014 "Secondary education" (in subject specializations) in 2015.

No.	Higher educational institutions (HEI)	Full-time			Extramural		
		L	S	E	L	S	E
1.	Luhansk National University, named after Taras Shevchenko	45	8	5	45	0	0
2.	Vinnytsia State Pedagogical university, named after Mykhailo Kotsubynskyi	-	-	-	-	-	-
3.	Rivne State Humanitarian University	60	18	21	60	5	8
4.	Izmail State Humanitarian University	30	10	24	30	2	0
5.	Pavlo Tychyna Uman State Pedagogical University	40	16	16	50	0	4
6.	Drohobych State Pedagogical University of name Ivan Franko	75	12	13	75	2	8
7.	Kremenets Regional Humanitarian and Pedagogical Institute, named after Taras Shevchenko	25	12	15	25	0	5
8.	Ternopyl Post Graduate Studies Centre of National Pedagogical University, named after Volodymyr Hnatiuk	-	-	-	-	-	-
9.	Kremenchuh Educational and Counseling point of Hlukhiv National Pedagogical University, named after Oleksandr Dovzhenko	-	-	-	-	-	-
10.	Kirovohrad State Pedagogical University, named after Volodymyr Vynnychenko	30	22	33	30	5	5

No.	Higher educational institutions (HEI)	Full-time			Extramural		
		L	S	E	L	S	E
11.	Kryvyi Rih National University	90	23	32	75	3	8
12.	Berdiansk State Pedagogical University	75	16	17	75	6	8
13.	Poltava National Pedagogical University, named after V. H. Korolenko	60	10	27	60	0	11
14.	Centre of Retraining and Continued Education of Drohobych Ivan Franko State Pedagogical University	-	-	-	-	-	-
15.	Kherson State University	40	8	9	25	0	1
16.	South Ukrainian National Pedagogical University, named after K. D. Ushynskyi	35	13	15	35	3	6
17.	Chernivtsi National University, named after Yurii Fedkovych	-	-	-	-	-	-
18.	National Pedagogical University, named after M. P. Drahomanov	100	20	25	100	5	6
19.	Pereiaslav-Khmelnytskyi State Pedagogical University, named after Hryhorii Skovoroda	50	20	20	30	4	4
20.	Zaporizhzhia Regional institute of Post Graduate Pedagogical Education	-	-	-	-	-	-
21.	Ternopyl National Pedagogical University, named after Volodymyr Hnatiuk	30	20	25	20	0	1
22.	Donbass State Pedagogical University	60	12	15	50	0	3
23.	Hlukhiv National Pedagogical University, named after Oleksandr Dovzhenko	75	17	18	30	2	3
24.	Khmelnytsk National University	30	10	22	30	0	2
25.	Chernihiv National Pedagogical University	130	45	50	130	0	3
26.	Sumy Educational and Counseling Point of Hlukhiv National Pedagogical University, named after Oleksandr Dovzhenko	-	-	-	15	0	0
	Total	1080	312	402	990	37	86

Table 2: Ratio of license volume, volume of state order, number of applicants, admitted to a speciality 015 "Vocational education" (in specializations) in 2015.

	Higher educational institutions (HEI)	Full-time			Extramural		
		L	S	E	L	S	E
1.	Kyiv National University of Construction and Architecture	130	25	27	50	0	-
2.	Luhansk National University, named after Taras Shevchenko	315	17	16	300	-	-
3.	International University of Economics and Humanities, named after academician Stepan Demianchuk, PHEE	25	0	-	25	0	-
4.	Kyiv National Economic University, named after Vadym Hetman	50	0	38	-	-	-
5.	Vinnytsia State Pedagogical University, named after Mykhailo Kotsiubynskyi	-	-	-	-	-	-
6.	Rivne State Humanitarian University	75	15	16	25	0	0
7.	Uman State Pedagogical University, named after Pavlo Tychyna	99	26	40	40	0	5
8.	Luhansk National Technical University	40	7	7	40	0	0
9.	Drohobych Sate Pedagogical University, named after Ivan Franko	50	5	5	28	0	0
10.	Podillia State Agricultural and Technical University	5	0	5	5	0	-
11.	National Transport University	60	12	12	-	-	-
12.	Kryvyi Rih National University	30	15	15	30	0	5
13.	Berdiansk State Pedagogical University	225	25	28	150	0	0
14.	East Ukrainian Volodymyr Dahl National university	100	9	1	100	0	0
15.	Poltava National Pedagogical University, named after V. H. Korolenko	60	5	13	-	-	-
16.	Anton Makarenko Kyiv Professional and Pedagogical College	50	0	0	40	0	0
17.	Stakhanov Educational scientific Institute of Mining and Educational Technologies (Kharkiv)	115	0	0	140	0	0
18.	Pryazov State Technical University	15	3	3	15	0	0
19.	Kherson State University	55	5	6	25	0	0
20.	Mukachevo State University	90	5	13	-	-	-
21.	Ukrainian Engineering Pedagogics Academy	-	-	-	-	-	-
22.	Postgraduate Education Institute of Engineering and Pedagogical educators of SHEE "University of Educational Management	140	0	4	100	0	0

	Higher educational institutions (HEI)	Full-time			Extramural		
		L	S	E	L	S	E
23.	South Ukrainian National Pedagogical University, named after K. D. Ushynskyi	30	0	4	-	-	-
24.	Chernivtsi National University, named after Yuriy Fedkovych	-	-	-	-	-	-
25.	Mykhailo Drahomanov National Pedagogical University	170	30	58	-	-	-
26.	Pereyaslav-Khmelnytsky State Pedagogical University, named after Hrihoriy Skovoroda	190	68	68	130	15	16
27.	Ternopil National Pedagogical University, named after Volodymyr Hnatiuk	25	20	24	-	-	-
28.	Educational-Scientific Professionally-Pedagogical Institute of Ukrainian Engineering and Pedagogical Academy (Artemivsk, Slavyansk)	300	8	20	280	0	0
29.	Mykolayiv National Agrarian University	50	0	0	50	0	0
30.	Donbass State Pedagogical University	30	5	6	-	-	-
31.	Kamyanetz-Podilsk National University, named after Ivan Ohiyenko	30	0	0	-	-	-
32.	Hlukhiv National Pedagogical University, named after Oleksandr Dovzhenko	60	0	0	100	0	0
33.	Khmelnytsk National University	15	2	2	30	0	0
34.	Kyiv National University of Technologies and Design	-	-	-	-	-	-
35.	Chernihiv National Pedagogical University, named after T. H. Shevchenko	50	10	9	50	2	3
36.	National University of Bioresources and Nature Use, Ukraine	-	-	-	-	-	-
37.	National Metallurgical Academy of Ukraine	25	5	11	25	1	1
38.	Kharkiv National Automobile and Highway University	50	8	13	-	-	-
39.	Educational-Scientific Professional-Pedagogical Institute (Artemivsk, Slaviansk)	25	0	0	50	0	0
	Total in Ukraine	2779	330	464	1828	18	30

Notes: L is license volume; S is volume of state order; E is the number of first-year students.

According to the information "Konkurs" ("Competition") system, 488 students were enrolled in the "Secondary education" specialty and 494 in the "Vocational Education" specialty in 2015.

Academies, universities, institutes, and colleges of Ukraine train technology teachers according to various profiles (table 3) (On approval of the list

of profiles of training at higher educational institutions, 2010; On the list of the specialties and their combinations, 2014; The Labour training at educational institutions, 3-6, 2003).

Table 3:   Profiles of training technology teachers in Ukraine

Specialism area	Training profiles	Proficiency
Vocational education	record management; design; commodity science; economy; ecology; computer science; mining; oil and gas engineering; metallurgy; materials science; mechanical engineering; welding; power engineering; electrical engineering; electromechanics; electronics; radio engineering; telecommunications and intercommunications; shipbuilding; metrology, standardization and certification; chemical technology; publishing and typesetting; technology of light industry products; food technology; woodworking; construction; transport; agronomical science; technology of agricultural products production and processing; forestry; zootechnology; hotel and restaurant business; consumer services; tourist services; labour protection.	• bachelor – a teacher of vocational training in the area; • master – a teacher-researcher, professional in the area (according to profile)
Secondary education	metalworking; woodworking; automobile engineering; agricultural production; technical and computer graphics etc.	• bachelor of technological education, a teacher of technology and drawing; • master – a teacher of general technical subjects and methods of teaching technologies.

The training of technology teachers is a complex integrative type of professional pedagogical activity involving interrelated professional and pedagogical, industrial, research, administrative, experimental, expert and consulting, and commercial types of activities in combination with the use, development, and implementation of innovations in the field of pedagogical technologies, innovative forms of educational process organization and management etc.

For training technology teachers, there are general requirements represented in the form of lists of competencies: social and personal, instrumental, scientific and professional competencies (general competencies and specific ones) (Educational qualification characteristic of the bachelor, 2012).

Social and personal competencies are as follows: *the* understanding and perception of ethical norms of behavior; to be aware of the necessity for

and maintaining norms of a healthy lifestyle; learning ability; criticism and self-criticism ability; creativity; systemic thinking ability; adaptability and sociability; persistence in achieving goals; concern about the quality of work performed; tolerance; environmental awareness.

General scientific competencies are as follows: knowledge of philosophy, psychology, and pedagogical basics contributing to the development of general culture and the socialization of personality, the tendency to ethical values, knowledge of national history, economics and law, understanding of causal relationships in the progress of society and the ability to use them in professional and social activities; basic knowledge of fundamental components of mathematics sufficient for mastering a mathematical apparatus of a corresponding specialism area, the ability to use mathematical methods in a chosen profession; basic knowledge in the field of computer science and modern information technology; skills ,needed to use software utilities and skills for working in computer networks; the ability to develop databases and use Internet resources; basic knowledge of fundamental sciences for mastering general professional disciplines; basic industry knowledge required for mastering general professional disciplines.

Instrumental competencies are as follows: the ability to write and communicate orally in one's native language; knowledge of a second language (languages); computer skills; information management skills; research skills.

Professional competencies:
1) general professional (basic understanding of technological objects' diversity; knowing how to apply the methods of observation, description, identification, and classification of technological objects; modern understanding of the principles of structural and functional organization of technological objects; ability to apply basic technological methods of analysis and assessment of industrial systems condition; modern understanding of the principles of technological objects produced on both physical and chemical bases; the ability to apply modern experimental methods while dealing with technological objects under laboratory conditions, skills of dealing with modern equipment; basic understanding of the main rules and modern achievements in technology, micro- and macro technology, understanding of the role of technologies in the context of world perception; understanding of rules concerning modern scientific and technical progress; basic vision of rules of the formation of technological objects; knowing how to deal with them; basic understanding of the basics of general, system and applied technologies, and

principles of industrialization; basic understanding of mechanical engineering, robotics, and labour safety; modern ideas concerning the basics of technology and engineering; theory and practice of technological principles, understanding of social and environmental effects of the professional activity; modern ideas concerning principles of monitoring and evaluating a state of environmental and wildlife protection in the industrialized world; ability to plan and implement relevant activities; knowledge of the legal basis for research as well as the legislation of Ukraine in the field of environmental protection and management; ability to organize work in accordance with the requirements of life safety and labour protection; business communication and team working skills in the professional area; ability to teach the basics of technological education);

2) specialized professional (ability to apply specialized knowledge in the field of mathematics (mathematical statistics) for statistical processing of experimental data and mathematical modeling of biological phenomena and processes; ability to use mathematical apparatus to master theoretical bases and application of technological methods; ability to use professionally profiled knowledge and practical skills in the field of mechanics, molecular physics and thermodynamics, electricity, magnetism, optics, nuclear physics for studying technical phenomena and processes; ability to use theoretical knowledge and practical skills for mastering the bases of theory and methods of technical research; ability to use specialized knowledge and skills in the field of fundamental sections of engineering for studying technological phenomena and processes; ability to use knowledge and skills in the field of technology for the theoretical mastering of general professional disciplines and solving practical problems; professionally profiled knowledge and skills in the field of the theoretical basis of computer science and practical use of computer technology; ability to apply skills for dealing with computers at the user level and to use information technology for solving experimental and practical professional problems).

While training, future technology teachers obtain necessary knowledge of three discipline cycles: humanitarian and socio-economic training; mathematical, natural-scientific training; and professional and practical training. Professionally oriented disciplines in the curriculum are as follows: Pedagogy, Psychology, Fundamentals of Technological Learning Theory, Vocational Teaching Methods, Bases of Visual Displaying, Bases of Art Objects Composition, Decorative Art, Artistic Processing of Materials, Technology of Structural Materials Followed by Practical Training, Bases of Clothing Man-

ufacture, Food Education, Computer Science and Computer Engineering, Information Technology and Modeling, and a Computer Practical Course.

The Combination of pedagogical and technological practices is the specific feature of professional training of future technology teachers. In the process of pedagogical practice, a student deepens and masters knowledge, improves knowledge and skills, implements his/her methodological equipment, organizes teaching-educational activities during lessons and after them, tunes herself/himself in personal communication with students. Third-year, fourth-year, and fifth-year students have practice teaching at secondary schools and colleges; sixth-year students have practice teaching at a higher educational institution. Practice teaching is a link between theoretical student's training and her/his future practical activity in an educational institution.

Future technology teachers do practical training in the first and second year (introduction into the activities of enterprises, factories, mass service institutions etc.); third, fourth, and fifth-year students perform their professional duties in the above-mentioned institutions as well as in specially designated laboratories of higher educational establishments. Their individual tasks for teaching practice are reflected further in research. During the practice, future technology teachers improve their professional competencies mastering the specifics of their future profession.

Higher education in the specific specialism area allows future technology teachers to hold such positions as: teacher of a vocational training institution; industrial training instructor; computer science teacher; lecturer of a higher educational establishment; assistant; junior researcher, methodologist of a higher category; teacher of a vocational educational establishment; industrial training foreman; and technology teacher. Being a teacher of general technical subjects and methods of teaching technologies at general educational institutions (secondary schools, upper secondary schools, and lyceums), at educational institutions of 2nd -4th accreditation levels, as well as at scientific and research institutions, he/she may be either a postgraduate student or be engaged in independent scientific/research activities.

The above-mentioned involves the development of an innovative approach to scientific and technical training of a teacher connected with transformation processes in a "Technologies" specialism area. The resolution "On the approval of State Standard of basic and full general secondary education" states that the purpose of a "Technologies" specialism area is the formation and development of production engineering, technological and information-communicative competencies to implement a creative potential of students and their socializing in society. Therefore, technology education as a

field is an important component of general secondary education promoting both the holistic and harmonious development of a child's personality. The State Standard of basic and full secondary education mentions that the main purpose of technology education is to form technically and technologically educated persons ready for life and active labour activities in the modern high-tech information society, to help students acquire vital knowledge as well as skills for housekeeping and family economy, learn basic components of information culture, provide conditions for their professional self-determination, develop skills for creative activities, learn about labour culture, implement pre-professional and professional knowledge according to their will and individual abilities (On approval of the State Standard of Basic and Complete Secondary Education, 2011).

The education field consists of information communication components and technological components.

Implementation of *the information -communication component* is aimed at the formation of subject-related information -communication competence and its key competencies.

The objectives of computer science training at secondary school are to develop students' skills to carry out basic operations with information objects, in particular:

- to search for necessary information using search engines and expert systems (the internet);
- to create information objects and then record, monitor and measure them within the implementation of individual and team projects;
- to propose and check simple hypotheses of educational and cognitive nature, to create, learn and use information objects;
- to use means of information and communication technologies for sharing information, communication;
- to plan and organize an individual and team activity in the IT environment.

In the field of Theoretical Computer Science, students:

- study and analyze information processes in wildlife, society and hardware;
- get an idea of principles of management, decision making, basic operation principles of information technology means;
- learn information modeling;

- develop algorithmic thinking as a means of planning and organizational activity.

In the field of Social Computer Science, students:
- learn about the role of computer science, information and communication technologies in the development of modern civilization, the IT infrastructure of a society, about main types of mass media and human interaction with such means;
- master legal and moral-ethical rules of operation with information data and software products;
- gain knowledge about information security of a society and an individual.

The objectives of Computer Science training at a secondary school are to develop such students' skills as:
- to identify and analyze the information processes in technical, biological and social systems;
- to design and use information models and means of describing and simulating phenomena and processes.

The main condition for implementing the technology component is the technology and information activities carried out from the creative concept appearance to its realization in the final product.

The objectives of Technology Education are as follows:
- the formation of a comprehensive view of material production development, the role of techniques, design and technology in the development of a society;
- students' introduction to the production environment, conventional, modern and advanced technology of material processing, arts and crafts;
- the formation of skills to develop the native culture assets using means of arts and crafts;
- gaining experience in the implementation of technological activities, partnership and value attitude to labour traditions;
- the development of students' technological skills;
- understanding of the importance of technology as a practical implementation of scientific knowledge;

- realization of students' skills and interests in the field of technological activity;
- providing conditions for self-realization, development of entrepreneurship and professional self-determination of every student;
- mastering the ability to evaluate their own results of a subject transforming activity and

the development level of key competencies and competencies in subject areas (On approval of the State Standard of Basic and Complete Secondary Education, 2011).

Modern technology education in Ukraine is focused on the student's practical activities; conditions for the implementation of a student's individual abilities during the lessons are provided. Technology training is based on the knowledge of processes of materials, energy, information, objects of natural and social environment transformation and usage. They have potential for development as they are largely focused on the interaction between a human being, techniques and technology. Students learn basics of production, innovative technologies, management activity, professions and the requirements for them. They are involved in creative intellectual and technological activities. Therefore, the teacher of technology should not only train each student to perform labour operations but also develop a technically educated person that is able to adapt to changes in the modern technological environment. For the mastering of technological regularities of transformation activities, professional self-determination can be carried out only if the structure of general secondary education has an appropriate branch of education. Its aim is to ensure the development of work culture, technical culture, practical knowledge and skills that reflect the common methods, means, processes, results and consequences of the knowledge, application and transformation of natural, artificial, and social environments, which aren't provided by any other area of general education.

Ukrainian scientists (V. Andrushchenko, I. Ziaziun, S. Sysoieva, M. Korets, O. Kobernyk, O. Kaligaieva, N. Nychkalo) examine theoretical and methodological problems of technology teachers training. They are related to: orientation to the transformation of a vocational training system from a traditional teacher to the teacher of production technologies; content development of scientific and technical training of future teachers of production technologies based on the European integration of scientific knowledge in techniques and technology; determination of disciplines aimed at the development of scientific and technical training of teachers of this specialty; integration of

disparate disciplines on the basis of the practical use of the training material in the school educational workshops; the elaboration of methods and teaching means of technical disciplines training aimed at the development of creative potential of future technology teachers; ensuring a higher scientific level of students' scientific and technological training according to the current state of techniques and technology development in the key industries (Korets, 2002; Andryshchenko et al., 2003; Nychkalo, 2010).

Therefore, technology teachers' training in Ukraine is in a multi-stage system of education (I, II, III accreditation levels), according to which the education qualifications: Junior Bachelor, Bachelor, Master, Doctor of Philosophy, and Doctor of Sciences are awarded. The regulatory framework in this process is "The Standard of Higher Education" and "Educational Program". There are two specialties for technology teachers' training in 56 Higher Educational Institutions. They are 014 – "Secondary Education" and 015 – "Vocational Education". The number of first year students in 2015 was 982. The training of technology teachers is focused on progressive changes in society, the emergence of new fields of scientific knowledge, and the introduction of new techniques and technology.

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