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CONSTRUCTING A MODEL OF DUAL PROFESSIONAL COMPETENCES IN ENGINEERING EDUCATION

Olena SOROKIVSKA | **Iryna STRUTYNSKA** | **Liliya MELNYK** | **Olha MYSHKOVYCH**

Ternopil Ivan Puluj National Technical University
56, Ruska str., Ternopil, 46001, Ukraine

e-mail: soroka220996@gmail.com
ORCID ID: https://orcid.org/0000-0001-8549-2910

e-mail: ringtons999@gmail.com
ORCID ID: https://orcid.org/0000-0001-5667-6569

e-mail: liliana.mel0512@gmail.com
ORCID ID: https://orcid.org/0000-0001-8844-5490

e-mail: mushkovuch_olya@ukr.net
ORCID ID: https://orcid.org/0000-0003-3136-0044

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Abstract. *The scientific research aims to describe the content and features of the introduction of dual education in Ukraine, to investigate the prospects and advantages of the formation of practical oriented engineering education, to construct a circular model of dual professional competencies of engineering education and to establish the interconnection of structural and functional subsystems of this model. Using the methods of the systematic approach, comparative analysis, synthesis, and generalization, the authors concentrate on conceptualising and formalising the dual content of engineering education.*

The authors analysed the curricula of individual engineering majors, identified several discrepancies in the correlation of theoretical and practical courses, proved the need to change the curricula and bring them closer to dual education standards.

To develop the dual content of specialists' professional training in the field of engineering, the authors suggest using the distinction the two subsystems – internal and external. The result of interaction between these two subsystems is the parallel acquisition of necessary applied engineering skills while studying at higher educational establishments, practical cooperation between higher educational institutions and leading enterprises of the region, rational alternation of theory and practice in the educational process. Our finding offers a significant contribution to further understanding the methodology involved in implementing the academic standards and highlighting discrepancies between traditional and dual education systems. Prospects for further research in this area may be studies on developing dual education in economic and humanities.

Key words: *dual system; engineering education; professional competences; development of professional activity; educational process.*

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1. Statement of the Problem.

At the present stage of the European integration processes development, problems arose due to imperfection of the interaction mechanisms between education and the labour market, the adequate preparation and employment of graduates of engineering specialities. Attempts to solve the problems of preparing young people for adaptation in the world of work appear both in domestic and foreign theory and practice. This system is practised in several countries, notably in Germany, Austria, and Switzerland and also for some years now in South Korea. According to a modern approach, the dual education results from regulatory and legal constraints of the study process and the real opportunity to make the educational sphere of Ukraine more progressive and pro-European. A full-fledged dual education would be launched in Ukraine, starting in 2021, and positively influencing economic development [18, p. 102].

One way to improve the quality of the educational process is to introduce dual education as a form of practically oriented engineering education. The main task of the introduction of the elements of the dual structure of education is to eliminate the main disadvantages of traditional forms and methods of training future qualified engineers, to bridge the gap between theory and practice, education and production, and to improve the quality of the training of skilled personnel taking into account the requirements of employers within the framework of new organizationally distinct forms of study. It is the implementation of the dual training system that opens up new perspectives in improving engineering education efficiency.

2. Analysis of Recent Research and Publications.

There is no single approach on how to determine the nature of dual education. Dual education is interpreted differently by economic thinkers and scientists. According to the classical approach, a dual education system combines apprenticeships in a company and vocational education at a vocational school in one course [3]. The term “dual system” comes from Latin dualism which means dual and is used in pedagogical terminology from the middle of the 60s of the last century in the Federal Republic of Germany to denote a new, more flexible form of organization of vocational training, combining theoretical training in an educational institution with parallel acquisition of practical skills at the enterprise.

The central goal of the dual system is to help students attain and develop competence in action so that they can meet current and future professional challenges and participate in defining their vocational lives. Because of on-going changes in society, economy and at the workplaces, the dual system has been under pressure of adaptation in order to further maintain its effectiveness and efficacy. Consequently, especially since the 1980s, many adjustment processes have taken place on different levels of the system, namely the institutions involved, the syllabi for the different venues, and the teaching-learning processes [7, p. 200].

Such foreign scientists as Rauner, F., Smith, E. [23] focus on the issues, concerns, prospects and principles of dual education. The other authors, such as Siecke, B. [26] and Steedman, H. [27] examine the dual education system in different countries. The main aspects of the dual education system in Europe have been described by Gerbery D. [8], Török E. & Kovacs Zs. [29], Melin, G. [16]. A few studies analyse the collaboration between universities and industry (Pogatsnik, M. [21]), advantages, and industry engagement on student learning (Saniter, A. & Jimenez L. [24]).

The Ukrainian scientist Mazur, V. [15] contributes to studying the dual education system in Ukraine. Scientist Khomenko, V. [11, p. 411] explores the use of acquisition of dual professional competences model of future engineers-teachers in the educational process. Both foreign and Ukrainian scientists have contributed to the definition of the dual education system. Euler D. [6] determines that the dual education understand the optimal combination

of theoretical and practical training in the college and the enterprise. Thanks to the dual system of education, students receive better knowledge and skills for their chosen profession. In other words, it is a system in which trainees most of the training time is devoted to practice on the enterprise, where they will work after college.

Concerning the term "dual education" Muhambetaliev S. & Kasymova A. [17, p. 123] defined dual education system as the ability of graduates to work with absolute dedication and performance, as already well aware of the enterprise's life and feel it is "their". This contributes to the consolidation of personnel and reduces turnover, which is extremely important for production. M. Gessler's study [9, p. 172] considers in detail the principles of dual education, the collaboration between companies and schools, analyses various forms of dual education systems in different countries through the concept of "the Dominant Role of the Companies", supporting members of a particular educational and working community, employing young people and people with limited physical abilities, etc. According to the author, the dual education system should, first of all, becomes an essential part of the education system and then the primary way to provide the business with human resources. P. Koudahl [13, p. 1901] explores the dual education as an instrument for delivering of the labour market with highly qualified labour which can adjust to new and changing conditions, the introduction of new technology. The author focuses on the "high mobility on the labour market" as a central component of the dual education and emphasizes that it secures tight connections between the educational system, business and enterprises because of the involvement in the educational processes. The scientist claims that the principle of dual education is a relatively cheap way to educate skilled labour compared to school-based educational systems within dual education.

Modern models of the dual system of education in different countries and the educational society have been generalized and systematized in the research of the above-mentioned scholars (Christensen, S. & Erno-Kjolhede, E. [4, p. 288]). At the same time, despite the intensified scientific research in this field, there is no complex research to improve the implementation of dual education elements in our country's engineering sphere.

3. Previously unsolved parts of the general problem

Thus, the scientific understanding of dual professional competences in engineering education has been conducted primarily within the activity that combines company efforts to increase profitability and efficiency with educational goals. Even in a large volume of scientific literature on dual education and educational strategies, becoming the practically oriented engineering competences has not yet defined in Ukraine. In this regard, it is relevant to study the main peculiarities in implementing dual professional competences model in engineering education.

4. Task Formulation.

This research aims to study the content and features of the dual education introduction in Ukraine, investigate the prospects and advantages of practically oriented engineering education, construct the circular model of engineering education dual professional competencies, and establish structural and functional subsystems interconnection of this model.

The research's working hypothesis assumes that education and training of graduates from engineering educational institutions will be of high quality if the optimal combination of practical and theoretical components of the educational process will be ensured.

5. Main Research Results.

To confirm or disprove the working hypothesis, the authors have researched a series of successive stages of studing process. The first stage involved exploring the background in implementing dual education in Ukraine. Having studied normative documents of the Government, the Ministry of Education and Science of Ukraine. We have discovered that there are some reasons for introducing the elements of the dual education system in Ukraine: Law of Ukraine "On Education"; Medium-Term Plan for Priority Actions of the Government for the period 2017-2020, Section III "Development of Human Capital", division 8: "Modernization of Vocational Education"; Order of the Ministry of Education and Science of Ukraine dated March 16, 2015 # 298 "On the introduction of elements of the dual system of training in the professional training of skilled workers". Thus, an experiment with introducing elements of the dual system of education has already started in Ukraine.

At the second stage, the authors analysed developing educational systems in the countries such as Sweden, Great Britain, Germany, and Japan, which points to the need to integrate the educational process and practice, which is the basis of high-quality training of skilled specialists. The authors also highlighted prospects and limitations of implementing dual education in Ukrainian educational system, used historical and content analysis method: to explore a variety of theoretical approaches and scientific considerations in the field of dual education in Ukraine and other countries.

At the third stage, the analysis of educational and professional programs and engineering specialities curricula were investigated. The authors analyzed syllabus and curricula of Ternopil Ivan Puluj National Technical University (branch of knowledge 12 - Information Technologies). The research was based on two components: 1 – all competencies specified in educational and professional programs were divided into three main directions according to the proposed model: organizational, technological and managerial; 2 – in the curricula of the studied engineering specialities, there was determined the part of theoretical training (lecture hours), practical and laboratory classes in the teaching load, as well as the position of practice in the total number of hours.

The fourth stage of the investigation involves integrating competencies in engineering education and introducing the dual professional competencies interconnection system by using a circular model. This is explained by the fact that the main problem of using structural-logical schemes as a traditional form of presentation of dual vocational training is the specificity of the educational process. It involves many elements that have a similar structure and similar logical connections, procedures, etc. This transforms the traditional structural-logical scheme into a disordered set of objects and links between them. One way to solve this problem is to present a system of dual competences in the form of a circular scheme with the allocation of its elements and two subsystems. The structural (internal) subsystem involves constructing an optimal structure of an educational institution's curricula and educational programs. Such a network will allow student-centred and problem-oriented training. It will also provide an opportunity to focus on the preparation of a qualified engineer by including in the curricula the most relevant courses, modules and case studies. The functional (external) subsystem results from the dualization of the structure of the content of educational preparation involve the simultaneous activities of a future specialist both as a student and as a direct executor/performer/worker of practical tasks future workplace.

In the 2017-2018 academic year Ministry of Education and Science of Ukraine began introducing elements of the dual form of education in 52 vocational (technical) education institutions in 25 regions within 54 professions. There were changes in the content of education and the educational process schedule following employers' requests, taking into account state standards for specific labour professions. The Ministry developed 19 academic standards projects based on a competent approach and module system. Close cooperation

with employers to expand the number of vocational (technical) education institutions, a list of occupations for introducing elements of the dual form of education in 2018-2019 in more than 100 educational establishments and an increase in the list of working professions, which are being trained with elements of the dual form of education started [10].

Dual education will introduce the following changes in the organization of the teaching and production process of the experimental educational institutions: change in the ratio of training time: theoretical training - 30%, production training and industrial practice will comprise 70% of academic hours; introduction of the module learning process: mastering the core module based on the institution of education, and then shifting model will apply: the module on theory (1-2 weeks) at the institution of vocational education / the module on practice (4-8 weeks) at enterprises, institutions, organizations.

Germany became the first country to use the dual education system principles for more than 15 years. Besides, there is a gradual complication of educational and practical tasks. It is known that vocational education in Germany, although it is decentralized, is structured under the standard. In Germany, since 1981, there are legislative acts such as "On the Promotion of Vocational Education" (describes the regulatory instruments in the field of planning and statistics of vocational education), the Law on the Occupational Health of Young People (substantiates the protection measures for young students), "Treaty about vocational training". Professional training is strictly in line with the List of Professions, which has now dropped from 600 (in 1971) to 380 professions. The reduction in the number of occupations occurred in connection with the integration of training specialists in similar activity areas. The dual education system's basic principles are parity of humanistic and value orientations, competence approach, formation and development of professional activities and socio-professional relations.

The practical experience of implementing the dual education system in Germany shows that most of the training directions for future specialists are regulated by an agreement between social partners, regions and the state. The training of specialists of a particular occupation is based on the job market's demands and requirements, which ensures young professional mobility and competitiveness. The training period varies for up to 3 years. Students who pass a practical part of their training at the enterprise receive a salary.

The system is funded by the state and enterprises. The state is responsible for training at the enterprise, and the region facilitates movement at a professional higher education institution. The enterprise altogether provides the learning process with modern equipment. Large enterprises and organizations allow trainees to study in their laboratories and workshops, small enterprises, however, do this in the workplace. The initial stage of training is directly related to covering industrial practice.

Consequently, a graduate of a higher educational establishment can demonstrate to a prospective employer a long-term practical experience of activities in the chosen professional field. The student who studies in the dual system framework is financially secure because he has/she receives a salary (though, modest one) while learning. However, it should be noted that a student spends less time studying the theory than those who study under the traditional system of vocational education.

Dual education is characterized by the possibility of receiving financial support from several sources; it is the lion's share of spending to take over the state. The primary purpose of non-state funding sources should be to create the newest educational laboratories, sites, and workshops with a high level of technical and resource equipment for training.

Ukrainian scholars see the following positive aspects in dual education: cooperation between politicians, businesses, social partners; development of the legislative basis for the recognition of national standards for the quality of vocational education; learning while working; attraction of qualified production personnel to pedagogical activity (instructors, teachers); carrying out institutional research and counselling (monitoring the quality of

educational services in the field of vocational education, updating academic standards); taking into account specific requests of enterprises for the content and quality of vocational education.

Among considerable disadvantages of the dual system of education is that in the curriculum, in-depth study of disciplines is given an insufficient number of hours due to the intensity of training. There is no vacation time for students, though they receive a certain amount of vacation leave. Apart from that, in the process of implementing the dual training of specialists the lack of an individual approach in the organization of activity which involves the development of educational trajectory for a particular student is considered to be a difficult task, thus, should be taken into account while developing syllabus [11, p. 411].

To determine the practicality of introducing the dual education system, the study's authors analyzed educational and professional programs and curricula of Ternopil Ivan Puluj National Technical University (branch of knowledge 12 - Information Technologies). The study was conducted based on two components: 1 - all competencies specified in educational and professional programs were divided into three main directions according to the proposed model: organizational, technological and managerial; 2 – in the curricula of the studied engineering specialities, there was determined the part of theoretical training (lecture hours), practical and laboratory classes in the teaching load, as well as the role of practice in the total number of hours.

The result of the division of competencies into organizational, technological and managerial is shown in Table 1.

Table 1. Division of competencies specified in educational programs into organizational, technological and managerial directions according to the proposed model[1]

The name of the speciality characteristics	**Code and title of speciality and level of higher education**				
	122 - Computer Science (first level - Bachelor)	**126 - Information Systems and Technologies (first level - Bachelor)**	**122 - Computer Science (second level - Master)**	**124 - System Analysis (second level - Master)**	**126 - Information Systems and Technologies (second level - Master)**
Number of general competences (according to educational program)	11	10	14	12	13
Number of professional competences (according to educational and professional program)	17	14	16	14	16
Total	**28**	**24**	**30**	**26**	**29**
among them:					
organizational competencies	4	2	5	7	6
% of the total number of competences	14,29	8,33	16,67	26,92	20,69
technological competencies	18	16	20	12	18
% of the total number of competences	64,29	66,67	66,67	46,15	62,07
managerial competencies	6	6	5	7	5
% of the total number of competences	21,43	25,00	16,67	26,92	17,24

[1] Compiled by the authors according to the educational programs of the studied specialties.

As a result of the study of competencies under three engineering specialities of two levels of higher education (Bachelor and Master), the following tendencies were identified:

1) in each of these specialities, the number of professional competencies exceeds the number of general competencies. This indicates that the emphasis is placed on the formation of professional education in the specified branch of knowledge. General competencies are an accompanying element of the educational process, and their central role is to provide necessary skills and the ability to obtain professional education;

2) most of the competencies obtained in the learning process are technological competencies. Their part in specialities ranges from 46.15% for speciality 124 - System Analysis (second level - Master) to 66.67% for specialities 122 - Computer Science (second level - Master) and 126 - Information Systems and Technologies (first level - Bachelor);

3) the part of organizational competencies is the lowest for speciality 126 - Information Systems and Technologies (first level - Bachelor) - 8.33%, its highest indicator is for speciality 124 - System Analysis (second level - Master) - 26.92%. In general, we can note that approximately only every fifth competency allows modern Bachelors and Masters to acquire skills in organizational activities concerning individual phenomena, processes, and executors;

4) the part of competencies in the field of management changes as follows: from the lowest indicator – 16,67 % for speciality 122 - Computer Science (second level - Master) to the highest value – 26,92 % for speciality 124 - System Analysis (second level - Master). Thus, we can note that managerial competencies also have a relatively low share in forming the general and professional competencies of Bachelors and Masters of the studied engineering specialities.

What could be the consequences of such a division? It is rational to explain them by using the development and promotion of start-ups carried out by engineering specialities students. According to the results of recent years, only every tenth start-up in Ukraine is successful. In 90%, start-up developers lack just organizational and managerial knowledge to form a perfect strategy, organize an effective team, and develop a productive marketing campaign. According to statistics, the main reasons for the loss of start-ups is the lack of a strategy (about 20% of the total number of reasons), an imperfect financing scheme and market promotion (18.5%) and an ineffective team, which is working on launching a start-up on the market (about 12%).

These problem moments are worsening because, for the studied engineering specialities, theoretical training today has a relatively high specific weight in the volume of classroom hours (Figure 1). Its share ranges from 42.42% for the Bachelor's level in the speciality "Computer Science" to 61.54% for the Master's level in the specialities "System Analysis" and "Information Systems and Technologies". Such a high level of lecture hours indicates excessive "theorization" of the educational process, insufficient attention to students' practical and laboratory work. It is also advisable to include such a factor as obsolete educational equipment in the laboratories of students of engineering specialities. As a result, we get a specialist who has a high level of theoretical training, but he/she is often unable to put his/her knowledge into practice.

The results of the study of the proportion of various types of practice in a total load of students of the studied engineering specialities showed a threatening tendency: for undergraduate students – education, industrial and technological training together account for only 3.75% of the total hours. For graduate students – the share of research, undergraduate and scientific-pedagogical practice is only 25% of the total hours. We can note that students' actual practical training, which is carried out at IT companies and enterprises, lasts a brief period and does not give students a real opportunity to study the production

processes at the practice site thoroughly. Thus, using the studied specialities as an example, we demonstrated a low level of organizational and managerial competencies acquired by students and an insufficient amount of the practical component in the educational process.

Substantiation and development of the concept of dual education for professional training of students in the engineering field is a complicated systematic task that requires careful analysis and elaboration. The co-conceptual general scientific principles of solving this problem include the conceptualization and formalization of the dual content of engineering education through a systematic approach.

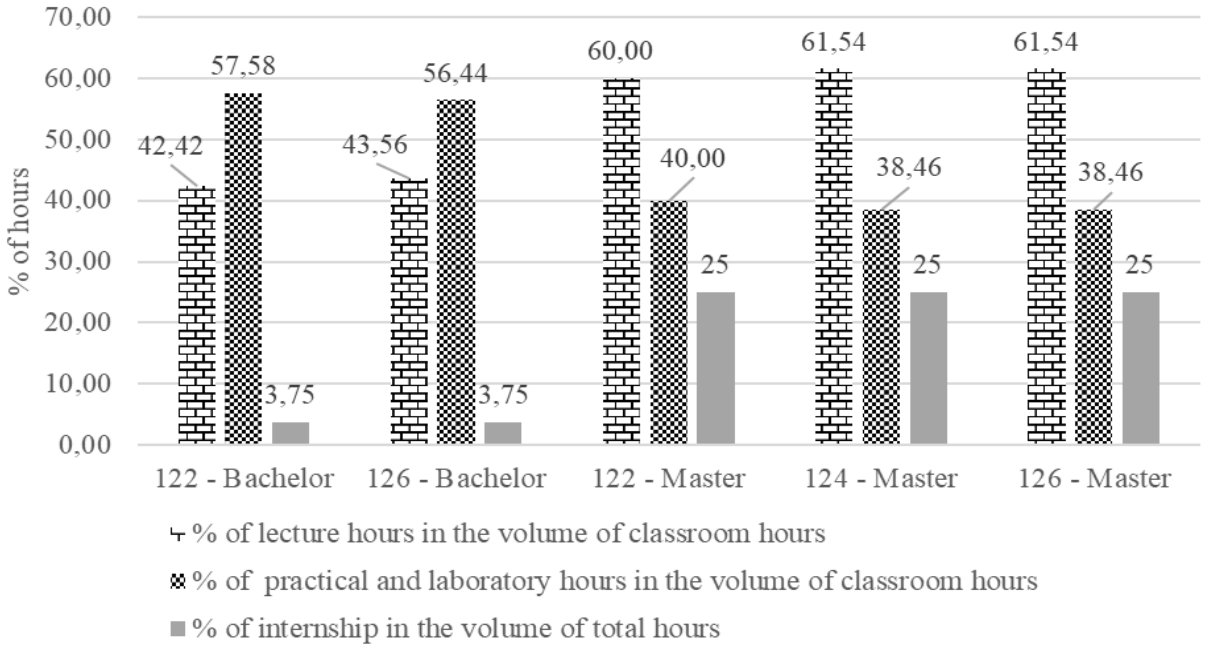

Fig. 1. The proportion of lecture, practical, laboratory and internship hours of engineering specialities students in the branch of knowledge 12 - Information Technologies[2]

In the process of training a specialist in the field of engineering education, he/she must acquire many professional competencies. They can be divided into three main areas: organizational, technological and managerial.

Since engineering activity is an inherently dual activity (combining theoretical knowledge and practical skills), it is determined by several dual competencies. In this sense, professional competence is the professional training and the ability of a future engineer to fulfil the tasks and responsibilities of a particular activity area. Thus, this professional competence is measured and qualified following professional activities. Since professional competence implies the ability to perform a specific type of action, it is advisable to characterize it from the activity approach's point of view. In this context, professional competence can be understood as one of the structural components of professional readiness for a particular type of activity. From this position, theoretically, it is possible to substantiate and technologically develop a system of multilevel (nonlinear) dual content of vocational training aimed at forming the necessary professional competences of a future engineer. One of the main requirements for developing such a system is the need to use hierarchical structures to represent interactive links in the scheme of dual professional competencies (Figure 2).

[2] Compiled by the authors according to the educational programs of the studied specialties.

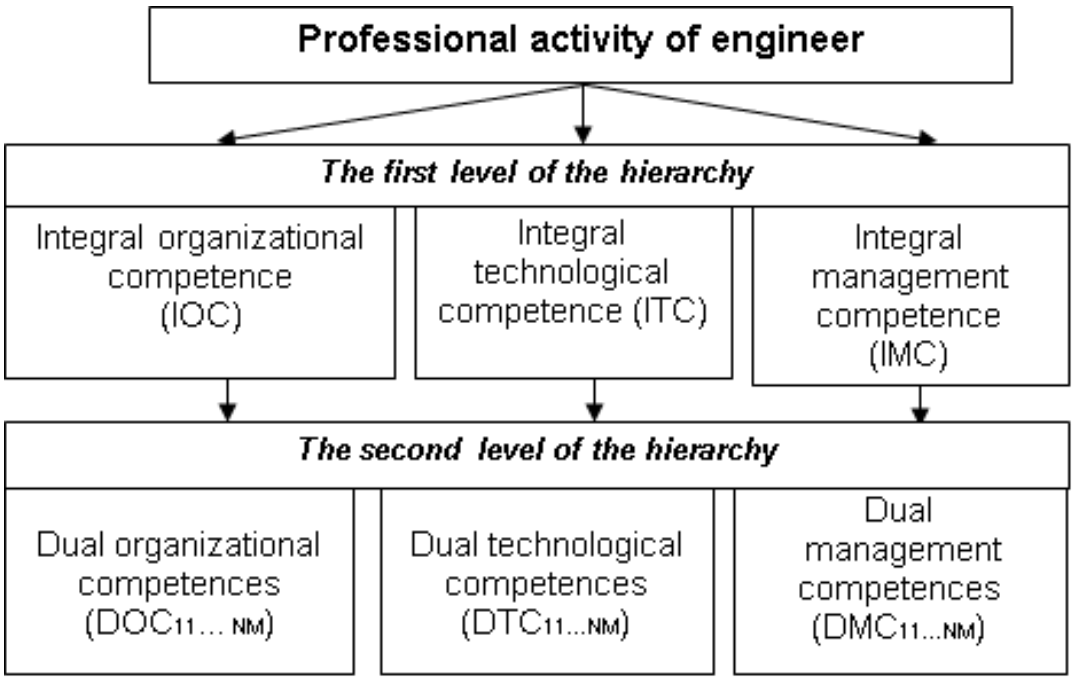

Fig. 2. The generalized hierarchical structure of the competence system of the future engineer[3]

The main advantage of using the n-sphere circular model concerning the traditional structural-logical scheme is the visibility of the description of objects, processes and phenomena of professional training by combining different levels' dual competencies into a coherent, logical model. In this case, each professional competence will be represented by a separate hierarchical group of dual competencies: dual professional competencies related to the appointment and use of the object of professional activity (U); dual professional competences related to the structure, composition and design of the object of professional training (C); Dual professional competences relating to the principle of the operation and functioning of the item of professional activity (F); Dual professional competences related to the parameters, characteristics and properties of the object of professional training (P).

We will present a generalized hierarchical model of dual professional competences in a circular form, using division into sectors to identify individual components within a hierarchical structure (Figure 3).

In this model IOC, ITC and IMC – necessary competences of the first level of the hierarchy; DOC_{11} …, DMC_{NM} – dual professional competences of the second level of the scale; DOC_{11U}…, DMC_{NMU} – dual professional competences of the third level of hierarchy which refer to the aim and usage of the object of professional competence; DOC_{11C}…, DMC_{NMC} – dual professional competences of the third level of order which refer to the structure, components and construction of the object of professional competence; DOC_{11F}…, DMC_{NMF} – dual professional competences of the third level of hierarchy which refer to the principle of activity and functioning of the object of professional training; DOC_{11P}…, DMC_{KNMP} – dual professional competences of the third level of hierarchy which refer to the parameters, characteristics and properties of the object of professional activity.

Our research has shown that engineering students' education and training do not provide a proper blend of theoretical and practical components. Therefore, it must be improved, in particular, towards the development of appropriate competencies following the market's requirements.

[3] Compiled by the authors.

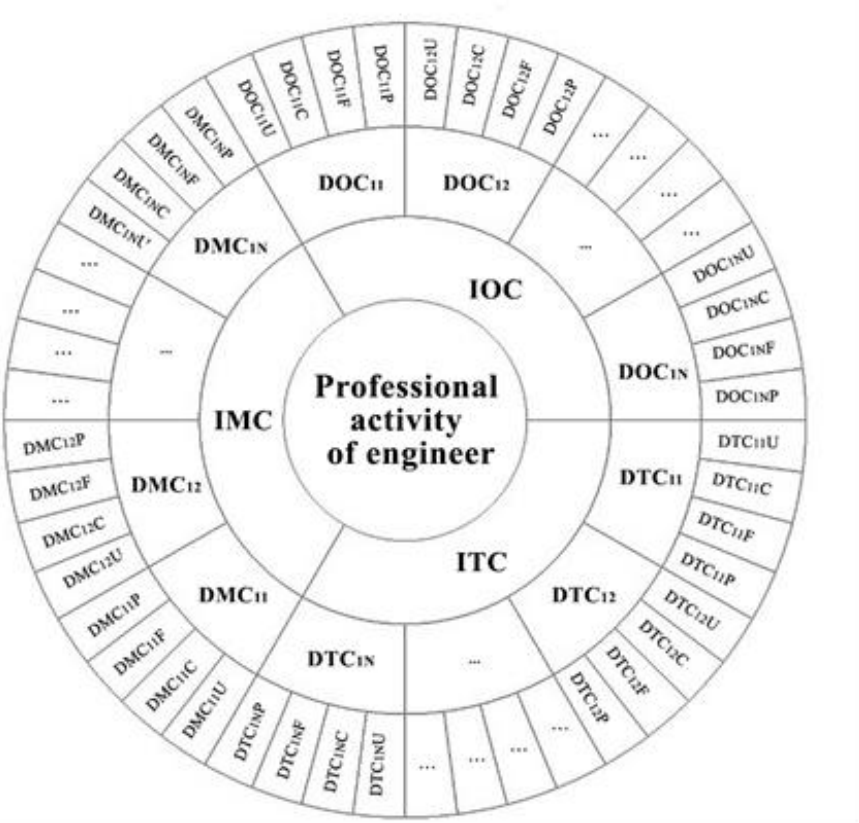

Fig. 3. Generalized circular model of the system of dual competences of the future engineer[4]

The conducted research has again demonstrated the contradiction between the vision of the national education system's educational results and the peculiarities of the educational process in the developed European countries. This confirms the importance of introducing a progressive European experience, the need for cooperation between higher education institutions, vocational schools, and employers to develop educational and vocational training programs and training plans. It promises to organize various forms of practical activity and internships for future and actual teachers, students in companies. It is crucial to regularly exchange experience on topical issues in college and university education and identify needs for change to bring education and training of future professionals closer to the urgent requirements of the economy.

The obtained results are confirmed by the results of similar studies in engineering and pedagogical education. In particular, Ukrainian scientists S. Tsymbaliuk, T. Shkoda, M. Artiushyna (2019) in cooperation with the representatives of the Institute of Professional Qualifications (Kyiv, Ukraine) have conducted quantitative research "Assessing and improving vocational teacher`s educational and Training in Ukraine" (a survey). The research results confirmed their hypothesis that college graduates' education and training (specialists) would be of high quality if it develops relevant practical competencies according to the employers' demands and the teachers' education and training provides forming these competencies in students.

That is why authors are sure that the proposed model of competency-based education of future engineers will help balance the educational process, strengthen the organizational and managerial skills of graduates of engineering specialties, focus on reducing the volume of theoretical load, and increase the efficiency of obtaining relevant practical knowledge. Implementing the proposed model is currently essential today because our country has

[4] Compiled by the authors.

already begun the process of significant changes in educational training at all levels. So, we believe that it should be given more attention to these qualities in education and training.

The main limitation of the study is the focus on Ukrainian educational institutions. Also, certain restrictions are related to using quantitative research: the authors analyzed the curricula of only one branch of knowledge. Further research should be devoted to estimating the quality of education and training of students obtaining Bachelor's and Master's educational level on different engineering specialities and fields of knowledge after changes made in study plans and the content of internships. It is important to determine students' readiness to the engineering profession and implementation educational innovations in their future engineering activities. From the scientific point of view, further research should be focused on determining the optimal balance between theoretical training and practical action, developing a mechanism for effective interaction between educational institutions and potential employers, and creating fundamental aspects of improving the quality of future engineers' education.

6. Conclusions and Further Research Implications.

Dual education in Ukraine has all the prerequisites for its effective implementation. It is the system of forming dual professional competences that bridge the gap between theory and practice in training future skilled engineers. It opens up additional opportunities for improving engineers' training; allows taking into account the requirements of employers regarding the formation of professional competences and assessment of future qualified engineers.

Based on our research, we found that it is appropriate to highlight the main requirements for the development of systems of dual content for the training of future engineers:

1. A dual system of education should include a large number of heterogeneous elements of the educational process, which can be regarded as systems that form hierarchical structures.

2. Dual learning should be characterized by interactive connections between qualitatively heterogeneous elements of the educational process. These ties will enable the combination of theoretical teaching and practical skills to be fully integrated. The leading interactive links here are the following links: "university-enterprise", "university-laboratory", "enterprise-laboratory", "laboratory-production unit".

3. To reduce the degree of uncertainty, it is necessary to develop a clear structure of the dual education system, the main aspects of which need to be reflected in curricula and educational plans.

4. The system of dual education must be determined by such properties as versatility and emergence. Versatility means that the system's effect as a whole will not be equal to the sum of the impact of each of its subsystems. After all, in each of these subsystems (organizational, technological and managerial), different effects may be incommensurable with each other. Emergence means that each element of the dual system's main objectives may not coincide with the whole system's goals. Individual modules of academic disciplines can have different directions and pursue other purposes of the educational process. This makes the educational process more versatile and studying more interesting.

The scheme of dual education encourages employers to invest in education, and as a result, they receive a well-trained employee; promotes more versatile professional development of students, forms new psychology of a young specialist; increases motivation for obtaining knowledge and acquisition of professional skills of future engineers provides a high degree of socialization, adaptation in the conditions of production close to reality. More than that, it promotes the development of standards for modern professions and creates new workplaces and jobs.

Author details (in Ukrainian)

ФОРМУВАННЯ МОДЕЛІ ДУАЛЬНИХ ПРОФЕСІЙНИХ КОМПЕТЕНЦІЙ В ІНЖЕНЕРНІЙ ОСВІТІ

Олена СОРОКІВСЬКА | **Ірина СТРУТИНСЬКА** | **Мельник ЛІЛІЯ** | **Ольга МИШКОВИЧ**

Тернопільський національний технічний університет імені Івана Пулюя
вул. Руська, 56, м. Тернопіль, 46001, Україна

e-mail: soroka220996@gmail.com
ORCID ID: https://orcid.org/0000-0001-8549-2910

e-mail: ringtons999@gmail.com
ORCID ID: https://orcid.org/0000-0001-5667-6569

e-mail: liliana.mel0512@gmail.com
ORCID ID: https://orcid.org/0000-0001-8844-5490

e-mail: mushkovuch_olya@ukr.net
ORCID ID: https://orcid.org/0000-0003-3136-0044

Анотація: *Метою статті є дослідження змісту та особливостей впровадження дуальної освіти в Україні, виокремлення перспектив та переваг формування практично орієнтованої інженерної освіти, побудова кругової моделі подвійних професійних компетентностей інженерної освіти і встановлення взаємозв'язку структурної та функціональної підсистем цієї моделі. Використовуючи методи системного підходу, порівняльного аналізу, синтезу та узагальнення, автори зосередили увагу на концептуалізації та формалізації подвійного змісту інженерної освіти.*

Також авторський колектив провів ретельний аналіз освітніх програм окремих інженерних спеціальностей. Це дало змогу виявити ряд розбіжностей у співвідношенні теоретичних та практичних курсів та довело необхідність зміни освітніх програм для наближення їх до стандартів дуальної освіти. Ці зміни мають стосуватися, насамперед, збільшення годин практичної складової та зменшенням обсягу теоретичних курсів.

Із метою розвитку подвійного змісту професійної підготовки фахівців в галузі машинобудування автори пропонують розглядати освітній процес із позиції двох його підсистем – внутрішньої та зовнішньої. Результатом взаємодії цих двох підсистем є паралельне набуття важливих прикладних інженерних навичок під час навчання у вищому навчальному закладі, ефективна співпраця між вищими навчальними закладами та провідними підприємствами регіону, раціональне чергування теорії і практики в навчальному процесі. Результати дослідження роблять внесок у більш глибоке розуміння методології послідовного впровадження академічних стандартів, підкреслюють розбіжності між традиційними та дуальними системами освіти, доводять необхідність суттєвого коригування освітніх програм із метою адаптації до вимог сучасного ринку праці. Перспективами подальших досліджень у цій галузі можуть бути наукові розвідки щодо розвитку дуальної економічної та гуманітарної освіти.

Ключові слова: *дуальна система, інженерна освіта, професійні компетенції, розвиток професійної діяльності, навчальний процес.*

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://sepd.tntu.edu.ua/images/stories/pdf/2021/21soaiee.pdf

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