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THE MODEL OF FORMATION OF PROFESSIONAL COMPETENCE OF FUTURE SOFTWARE ENGINEERS

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The rapid technological development of modern society fundamentally changes processes of production, communication and services. There is a great demand for specialists who are competent in recently emerged industries. Moreover, the gap between scientific invention and its wide distribution and consumption has significantly reduced. Therefore, we face an urgent need for preparation of specialists in higher education that meet the requirements of modern society and labour market. Particularly relevant is the issue of training of future software engineers in the system of master's degree, which is the level of education that trains not only professionals, but also scientists and university teachers. The article presents a developed model of formation of professional competence of future software engineers in the system of master's degree. The model comprises units of training of future software engineers, identifies methodological approaches, a number of general didactic and methodological principles that underpin learning processes in higher education. It describes methods, forms of organization and means that are used in the system of master's degree, and also provides pedagogical conditions of effective implementation of the model. The developed model addresses the issue of individualization, intensification and optimization of studying. While developing the model, special attention was paid to updating the content of education and searching for new organizational forms of training of future software engineers.

Keywords: *model, software engineer, professional competence, the system of master's degree.*

Problem statement in a general sense and its relation to important scientific and practical tasks. Education system is compelled to seek pivotal ways to solve tasks of training required by the society. A modern software engineer should be able to be flexible in dealing with situations pertaining to professional activities, in particular, to track trends of development in the IT sphere, to identify promising and in-demand at the labor market areas of work for an IT specialist, and to learn and master them on their own; be able to work in a team, be communicative and be able to teach others (which is one of the essential requirements for career advancement in some IT companies). It is particularly important to be able to think critically, to have a creative approach to problem solution, to work in indefinite conditions. These defined requirements to a specialist can be provided during the educational process in the system of master's degree.

Analysis of recent research of the issue. Issues of educational reform, in particular, informatisitaion, are covered in works of Ukrainian and foreign scientists V. Bykov, L. Belousova, Yulia Goroshko, A. Gurgiy, M. Zhaldak, V. Klochko, N. Kuzmina, V. Kukharenko, A. Manako, N. Morse, E.Polat, V. Oleinik, S. Rakov, J. Ramskiy, Z. Saidametova, V. Soldatkin, A. Spivakovsky, A. Spirin, S. Semerikov, Y. Trius and others. A. Moroz, V. Moroz, Z. Slepkan, V. Bondar were involved in looking for ways to improve the efficiency of students training. V. Akimenko, P. Dening, N. Duhanina, I. Ermakov, G.Zholtkevich, D. Knut, M. Lazarev, I. Mendzebrovsky, T. Morozova, M. Nikitchenko, V. Osadchiy, Y.Peroganich, Z. Seydametova,

S. Semerikov, V. Sukhomlin, I. Teplitsky, G. Sharan, D. Shedrolosyev etc investigated theoretical and methodical aspects of training of IT-specialists in different periods.

At the same time the analysis of national and foreign scientific works on the formation of professional competence of future software engineers in the system of master's degree reveals lack of development.

The purpose of this article is to ground the structural and functional model of formation of professional competence of the future software engineer in the system of master's degree.

Summary of the main text of the study. One of the important terms of our study is the model. In scientific literature there are different approaches to the interpretation of this term. So, the Pedagogical Encyclopedic Dictionary provides the following definition of the term *model*: "... analogue of a certain fragment of natural and social reality that serves to store and develop knowledge about the original, to design the original, to transform, and manipulate it" [8]. There is another interpretation of the term *model* given in the Dictionary/Reference Book On Pedagogy: "a model is a diagram, picture or description of a phenomenon or process in nature, society; an analogue of a certain fragment of natural or social reality" [11].

I. Pidlasy defines the *model* as "...a mentally conceived or materialized system that adequately reflects the subject of the research and is able to replace it so that the study of the model enables to obtain new information about this object" [9]. Our study finds the definition of the *model* by V. Agupova the most appropriate, it states that "... the *model* is a symbolic system, which can be used to reproduce the didactic process as the subject of study, to show the integrity of its structure, functioning and to maintain this integrity in all phases of the study" [12].

The modeling method is widely used in pedagogy to study certain phenomena, by means of feasibility demonstration, construction and experimental testing of built models of particular values, phenomena, structures, and activities. Such outstanding scholars as S. Arkhangelsky, I. Blauberg, J. Gastev, V. Glushkov, A. Dehn, M. Klarin, G. Sukhodolsky etc were working on modeling of pedagogical processes and systems.

The concept of *formation* is considered in pedagogical literature mainly as a process, result, and both process and result together. Having examined scientific works of Y. Babinskogo, V. Slastionina, T.Stefanovska and others, the definition of I. Podlasiy appeared to be the closest to our study. Thus, we will consider *formation* as a process of development of a person as a social being under the influence of each and every factor – environmental, social, economic, ideological, psychological etc [9: 27].

In psychological and pedagogical works we find such concepts as *competence, skills, professionalism, professional competence, qualification characteristics, job profile diagram of a person, professional maturity* and others to define a set of requirements to the personality of a professional. We hold with the following definition of S. Martynenko: "professional competence is the motivation for choosing a certain type of work, qualitative psycho-physiological changes among representatives of different professions, the influence of professional activity on the formation of "I-concept", obtaining professional maturity by a person, gaining a certain level of professional (vocational) competence by an employee [4].

We conceive the term *professional competence of a future software engineers,* being a result of training for master's degree, as a combination of professional, communicative, and personal abilities and qualities, knowledge and professional skills, which provide the capability to carry out professional activities to achieve an intended result.

Particularly relevant is the issue of training of future software engineers in the system of master's degree, who can combine research and mastering of new technologies and teaching skills in their future professional activities. The objective of the system of master's degree is training of professionals able to carry out professional activities effectively in untypical or uncertain environments, as well as training of future scientists and professors. Therefore, software engineers who have obtained the master's degree can accelerate the introduction of new technologies into the education system, facilitate close collaboration between practitioners and scientists.

According to the analyzed definitions we face the task of developing a model of formation of professional competence of future software engineers in the system of master's degree.

The difficulty of development of this model consists in changing of the system of higher education standards, which is currently in progress, as well as in the lack of professional standards of masters of software engineers according to the new list of professions.

We have analyzed scientific and methodological works on training of software engineers, our own professional experience as a software engineer in an IT company and a university teacher, requirements of employers to candidates for certain positions in an IT company, conditions and requirements of career growth in IT sphere using the example of Data Art company, and cooperation between universities and IT companies in terms of cluster collaboration, joint activities. All this gave the opportunity to identify the main components of the model of formation of professional competence of a future software engineer in the system of master's degree.

The model presupposes changes in all components of the higher education system, such as defining goals, learning content, and also search for new learning technologies and efficient organizational forms to achieve the goals. The model consists of six units: target, methodological, unit of pedagogical conditions, content unit, activity oriented unit, and diagnostics and effectiveness one.

1. **Target unit** involves determining the goals and objectives of formation of professional competence of a future software engineer in the system of master's degree in accordance with the society requirements, which are expressed by the regulatory framework and professional standards (previously the regulations were made by educational qualification characteristics and educational and professional program).

2. **Methodological unit** includes components of professional competence, which are important for our research, principles and approaches (competence, personal and activity oriented), regularities and rules.

Personal and activity oriented approach to learning (I. Zymnia, N. Kuzmina, etc.) is traditional in the education system. This approach combines person-centered (I. Bondarevska, K. Platonov, V. Serikov, O.Khutorskiy, I. Yakymanska) and activity oriented (A. Verbitsky, L. Vygotsky, P. Galperin, O. Leontyev, N. Talyzina, V. Shadrikov, D. Elkonin) approaches. It was chosen due to the need to identify features of training of future software engineers for professional activities and to reveal the opportunities for self-improvement in the system of master's degree. The current level of IT industry defines clear requirements for the personality of professionals, which can be formed and manifested only in the process of practical professionally oriented activities. According to I. Zymnia, the personal and activity oriented approach allows us to consider the personality "as a subject of activity, which itself is formed during activities and fellowship with other people, determines the nature of this activity and fellowship himself" [2: 75]. The competence approach was developed N. Bibik. Y. Bykov, I. Zymnia, N. Morse, A. Ovcharuk, L. Petukhova, A. Pometun, I. Rodygina, G. Selevko, O. Spivakovsky, A. Khutorsky, S. Shishov and others. O. Pometun defines *competence approach* as the focus of the educational process on the formation and development of key (basic, main) and subject competences of an individual [4]. The competence approach in the educational process in the system of master's degree is manifested primarily in the formation, intensification and refining of students' knowledge in the chosen professional activity and is of a particular importance in the process of training of future software engineers on account of a quick change of technologies.

3. **Unit of pedagogical conditions** determines conditions of formation of professional competence of future software engineers in the system of master's degree and includes the formation of a positive, professionally oriented motivation of future software engineers, activation of reflexive processes in the course of educational interaction, intensification of the process of master's training and convergence of academic work with real environments by means of cooperation with IT companies.

It is crucial to define conditions for effective implementation of the developed model. Therefore, we are to analyze such concepts as *conditions*, *pedagogical conditions*, *didactic*

conditions, types of pedagogical conditions. So, S. Ozhegov defines *conditions* as a set of interrelated and interdependent circumstances in the process of activities. A. Kapshuk considers this concept as a set of objective possibilities of content, forms, methods and material and spatial environment, aimed at solving tasks [2]. V. Andreev notes that pedagogical conditions are the result of purposeful selection, design and application of training forms to achieve didactical goals [1]. O. Osipova uses the term *organizational and pedagogical conditions*, which she presents as a set of necessary and sufficient measures, which create the most favorable environment for the model implementation [6: 189]. O. Piekhota considers pedagogical conditions as the category which is a system of specific forms, methods, material conditions, real situations that happened objectively or were subjectively created, and which are indispensable to achieve educational goals [7].

In our study we will interpret the concept *pedagogical conditions* as a system of necessary measures for the most favorable implementation of the model. To determine pedagogical conditions of formation of psychological and pedagogical competence of future software engineers in the system of master's degree, we will rely on a threefold system of pedagogical conditions, which contains the following conditions [12]:

- methodological, that is, standards established in pedagogy and psychology, the use of which enables to carry out a productive cognitive system of actions and increase the probability of obtaining a reliable positive result. In our study we relied on personal, activity oriented and competence approaches;
- methodical, namely objectives, content, methods, forms and means of training of future software engineers in the system of master's degree;
- organizational and pedagogical.

Note that the defined units of the pedagogical conditions are interconnected and are implemented sequentially. At the stage of implementation of the chosen methodological conditions in the process of formation of professional competence of a future software engineer in course of obtaining the master's degree, they acquire the status of methodical conditions, which determine the peculiarities of the training process of masters for teaching activities at universities and IT companies, and ensure compliance through development of methodical system of formation of the studied phenomenon. The next logical step is the introduction of the methodical system, in which methodical conditions become decisive for organizational and pedagogical conditions, which govern the preparation and conduct of training of future software engineers in the system of master's degree, aimed at formation of professional competence.

4. **Content unit** includes the content of training of future software engineers selected in accordance with the purpose, in particular, the content of the disciplines associated with cloud technologies and the Internet of Things, such as *Cloud Technologies In Education*, *The Internet Of Things* and *Programming Of Microcontrollers And The Internet of Things*. The content unit is of a particular importance, since the content of education of future software engineers should reflect the current state of the technology development, so it should be updated regularly. Regular update of the education content in the system of master's degree is vital in ensuring fulfillment of the objective, i.e. formation of professional competence of future software engineers in accordance with the requirements of information community and labour market. The content of professional activity of the master in software engineering is implemented through practical skills, which outline the boundaries of content and operational activity oriented components of formation of professional competence.

Update of content components of training of future software engineers occur in steps presented in Figure 1. Some steps are better performed in parallel rather than sequentially. Let us have a closer look at some of them. Research of trends in development of the IT industry and the scope of technologies in-demand (step 1) required studying of practical experience of leading IT companies and some relevant studies.

To develop modern training courses in cloud computing and the Internet of Things it is important to raise your own level in the selected areas, to master new technologies (step 2). To this

effect we participated in training sessions of leading developing companies, in particular, *Microsoft Azure development* and *Windows Azure* (by Microsoft), *The Internet of Things* (by DataArt).

Modern life is defined by the appearance of a wide range of information and communication technologies, such as cloud computing, robotics, the Internet of Things, big data, etc., which can change the way of life of the society, and contribute to the creation of a significant number of new jobs. However, the complexity of implementing of these technologies in the educational process in modern conditions is caused by the need to create a technical base, which requires significant investments from universities (step 3). One of the possible solutions may be co-financing by means of attracting funds from international grants, partnerships with corporations that develop the technologies and so on. Thus, two laboratories were established in SNPU named after K. D. Ushynsky: one in cooperation with Microsoft, and the other one with Intel.

However, there is a need to organize access to established laboratories for students from other educational institutions, scientists and industrialists. This problem can be solved by establishing regional technology centres and introducing new organizational forms of cooperation of all stakeholders. An important step is training of teachers of higher educational institutions in the field of new technologies. Therefore, in February and March 2015 we carried out training of University teachers in *The Internet of Things* on the basis of the South Ukrainian National Pedagogical University named after K. D. Ushynsky, together with DataArt and Intel.

Updating the content of education (step 6) can be done through changes in the curricula of new disciplines or content update of already existing ones. Note that certain modules of *Cloud Technologies In Education* and *The Internet Of Things* were included in other training courses such as *New Information Technologies*, *Multimedia Learning Technology*. Such approbation of training courses' modules in *The Internet Of Things* and *Cloud Technologies In Education* in educational process of SNPU allowed us to begin developing options of these courses for students of technical universities, in particular, for future software engineers.

Conduct of the educational process requires search for new organizational forms due to the lack of public access to a technological base. Monitoring of training results should be regularly compared with the demands of the society, the labour market and the development level of new potentially required technologies. If appropriate, steps should be repeated. Changes in any large system are running very slowly due to its inertia. To guarantee training of software engineering masters at a high level and in accordance with social demand, the system of training of future software engineers requires regular update of the technological base, of the content components and professional development of teachers in ICT.

5. **Activity oriented unit** is a list of forms (traditional and computer-oriented (by Yuri Trius) and innovative), methods and tools.

Traditional forms of training in the system of master's degree include lectures, practical, laboratory and independent work, seminars, consultations, final work. *Computer-based forms* of training organization are audio or video lectures, online written and oral testing, webinars, individual and group online projects, web-conferences, web-discussions and consultations in the use of ICT, organized by means of forums, chats etc.

Note that fast change of programming technologies, development and wide application of new digitally controlled devices in all spheres of society justify a need for a continuous updating of education content of training of future software engineers and search for new forms of training organization. One of the promising forms is project activities, hackathons, etc. in close cooperation with IT companies. Such organizational forms we assign to *the innovational*.

Among training *methods* there are some important ones such as the method of "reverse" teaching, the method of projects, situation modelling, brainstorming, the method of unfinished solutions, the method of electronic portfolios, the role-play method, case study, master's practice, the method of collective self-studying.

Among the training *means* we will mention only those that are specific to teaching of the new education content. *Hardware* is of a special importance, for instance, mobile devices, computers connected to the Internet, Devicehive Galileo Discovery Platform laboratory stands

(development by DataArt on the basis of Galileo 2 microcomputer from Intel); *software*: cloud-based Office 365 services from Microsoft and Microsoft Azure or open-source cloud platform DeviceHive developed by DataArt, the development environment the Arduino IDE for programming Intel Galileo Gen 2 microcontrollers.

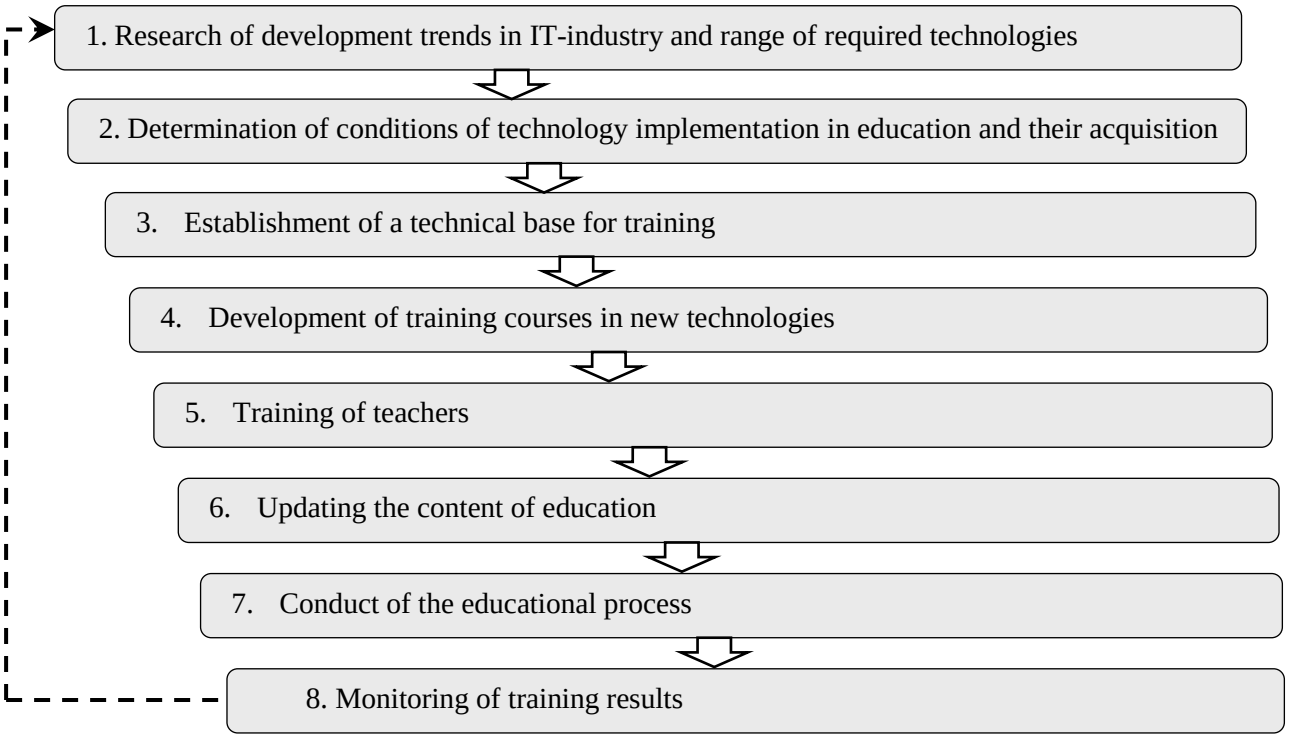

Fig. 1. Steps of updating content of education.

6. *Diagnostics and effectiveness unit* defines the criteria and indicators of formation of professional competence of future software engineers for the following levels: low, medium and high. It resulted in increase of the level of formation of the phenomena under research. The result is compared with expectations and, if appropriate, there is a correction of the components of the developed model.

Taking into consideration rapid technology changes and features of professional activity of a software engineer, we find that the internal motivation for effective professional activity and consideration is the basis for professional development of the individual. That is, these two components are key to the formation of professional competence, making up of personality of a professional, inspired and creative professional activities. However, professional knowledge and skills, as well as conformity of personal qualities of the future software engineer with professional requirements, are crucial. A modern software engineer should be able to manage complex professional issues, which requires knowledge integration, practical abilities and skills in IT related sciences such as economics, pedagogics, a foreign language, technology and others. The following qualities are required from the personality of such an expert today:

- responsibility, patience, persistence, attention to details and willingness to check and consider every detail, commitment;
- sociability, friendliness, ability to work in a team;
- independence, ability to self-education and quick mastering of new technologies, flexible thinking;
- ability to work in stressful situations, to make decisions in conditions of limited time;
- a broad outlook and ability to master a relevant area connected with project tasks quickly;
- developed critical, operational and creative thinking;

- design of their own professional growth, awareness of professional prospects.

Assessment criteria should correspond to the objectives and the content of control, and reflect the essence of professional competence. Thus, the analysis enabled us to determine components of the studied phenomenon, considered as the criteria of formation of professional competence of future software engineers in the system of master's degree, namely:

- the value and motivational component (the person is focused on the profession and is satisfied with it, has and is aware of the prospects of his professional development as a university teacher, is focused on increasing the prestige of the profession, is highly motivated to achieve goals);
- the reflexive component (conscious perception of itself as the subject of the educational process aimed at choosing the style of interaction, management and communication; awareness of responsibility for results of the activities; the ability to recognize and analyze their own mistakes; self-assessment of professional level and definition of the program of personal and professional development);
- the meaningful component (a set of special (relevant) knowledge necessary for productive activities; a reasonable justification of their own thoughts regarding management of professional situations);
- the operational and technological component (a set of skills required for the practical solution of tasks in the course of professional activities, in particular, decision making in everyday and extreme conditions of professional activity, the choice of programming technologies, activities monitoring, evaluation of activities of the project participants, adequate self-assessment of the importance of personal participation in cooperative work; correction of personal behavior);
- the personal component (a set of professionally important personal qualities of a specialist, important for the performance of professional activities).

Analysis of scientific pedagogical works on the issue of the research enabled determination of different approaches of scientists to definition of levels of competence development. Most scientists adhere to a three-level system of results assessment of professional (vocational) competence development, using different names for the levels. The three-level system uses the following names of the levels: low (reproductive or initial), medium (complicated), high (creative). A number of scientists adhere to a four-level system and classify the results of formation of the phenomenon under study into the following levels: low (basic), medium (reproductive), high (productive), creative. In his study we stick to the three-level system of results assessment of formation of professional competence of future software engineers, namely: low, medium and high levels.

Thus, the developed model of professional competence formation of a future software engineer in the system of master's degree is presented in figure 2. The model was tested in training of software engineers at Odessa National Academy of Telecommunications named after O.S. Popov, Kherson National University, Melitopol National Pedagogical University named after Bogdan Khmelnitsky. Some elements of the model were tested in the process of masters training for other professions on the basis of the South Ukrainian National Pedagogical University named after K. D. Ushynsky, in particular, using materials of the course in *Cloud Computing In Education*.

Analysis of the world tendencies in the field of information technologies development reveals an extension in requirements for pedagogical and personal qualities of a future software engineer. There is a growing variety of areas of programming. Due to fast technology advancement, the programmer is constantly forced to learn new materials and, when he grows older, he has to either change his career or move on to another level, or to a related professional activities industry. Analysis of the experience of IT companies shows that the most typical examples are the transition to teaching and consulting in financial and banking field or logistics. Further professional growth requires training in the system of master's degree, which generates the essential components of the professional competence of future software engineers.

Teaching courses in *Cloud Computing In Education*, *The Internet Of Things* and *Programming Of Microcontrollers And The Internet Of Things* based on the offered model helps to build masters sense of professional success, is a factor of influence on increasing the motivation to studying, professional interest of students and implementation of pedagogical communication, involvement of students in various forms of research activities.

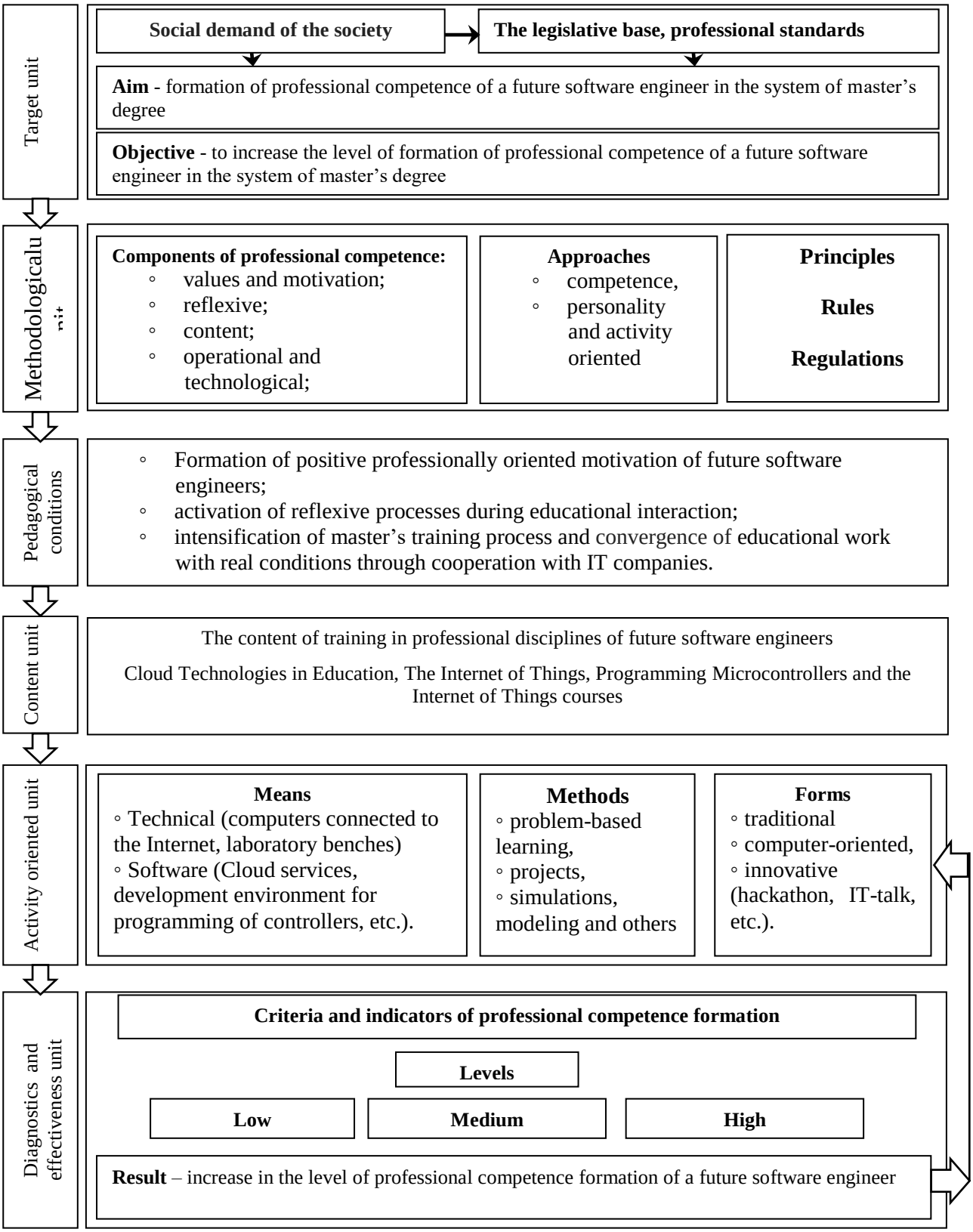

Fig. 2. The model of professional competence formation of a future software engineer in the system of master's degree.

Conclusions and prospects for further research. The study confirms the fact that the effectiveness of training in universities is possible on the basis the developed structural and functional model of formation of professional competence of future teachers of software engineers. The designed model consists of six units: target, methodological, content, activity oriented, diagnostics and effectiveness, as well as defined pedagogical conditions promoting formation of professional competence of future software engineers in terms of training in the system of master's degree.

The obtained results enable us to define some prospects of further research aimed at extension of training courses based on the developed model of formation of professional competence of future software engineers in the system of master's degree, together with extending of the list of professions which can use certain components of the model.

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МОДЕЛЬ ФОРМУВАННЯ ФАХОВОЇ КОМПЕТЕНТНОСТІ МАЙБУТНІХ ІНЖЕНЕРІВ-ПРОГРАМІСТІВ

Швидкий технологічний розвиток сучасного суспільства кардинально змінює процеси виробництва, спілкування, надання різноманітних послуг. Затребуваними стають фахівці, що володіють компетентностями у галузях, які виникли нещодавно. Значно скоротився термін між науковим винаходом та його широким розповсюдженням та споживанням. Актуальною стає проблема підготовки фахівців у вищому навчальному закладі, що відповідають вимогам сучасного суспільства та ринку праці. Особливо актуальною є проблема навчання майбутніх інженерів-програмістів у системі магістратури – освітнім рівнем, на якому готують не просто фахівців, а науковців та викладачів ВНЗ. У статті представлено розроблену модель формування фахової компетентності майбутніх інженерів-програмістів у системі магістратури. В моделі представлені блоки підготовки майбутніх інженерів-програмістів, визначені методологічні підходи, ряд загальнодидактичних та методичних принципів, на які спирається процес навчання у вищому навчальному закладі. Описані методи, форми організації та засоби, які використовуються в системі магістратури, а також висвітлені педагогічні умови ефективної реалізації моделі. Розроблена модель розв'язує проблеми індивідуалізації, інтенсифікації та оптимізації навчання. В процесі розробки моделі особливу увагу було приділено оновленню змісту освіти та пошуку нових організаційних форм підготовки майбутніх інженерів-програмістів.

Ключові слова: модель, інженер-програміст, фахова компетентність, система магістратури.

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МОДЕЛЬ ФОРМИРОВАНИЯ ПРОФЕССИОНАЛЬНОЙ КОМПЕТЕНТНОСТИ БУДУЩИХ ИНЖЕНЕРОВ-ПРОГРАММИСТОВ

Быстрое технологическое развитие современного общества кардинально меняет процессы производства, общения, предоставления различных услуг. Востребованными становятся специалисты, обладающие компетенциями в области, которые возникли недавно. Значительно сократился срок между научным изобретением и его широким распространением и потреблением. Актуальной становится проблема подготовки специалистов в высшем учебном заведении, соответствующих требованиям современного общества и рынка труда. Особенно актуальна проблема обучения будущих инженеров-программистов в системе магистратуры образовательном уровне, на котором готовят не просто специалистов, а ученых и преподавателей вузов. В статье представлена разработанная модель формирования профессиональной компетентности будущих инженеров-программистов в системе магистратуры. В модели представлены блоки подготовки будущих инженеров-программистов, определены методологические подходы, ряд общих дидактических и методических принципов, на которые опирается процесс обучения в высшем учебном заведении. Описаны методы, формы организации и средства, которые используются в системе магистратуры, а также освещены педагогические условия эффективной реализации модели. Разработанная модель решает проблему индивидуализации, интенсификации и оптимизации обучения. В процессе разработки модели особое внимание было уделено обновлению содержания образования и поиска новых организационных форм подготовки будущих инженеров-программистов.

Ключевые слова: модель, инженер-программист, профессиональная компетентность, система магистратуры.