



UDC 378.147.016:004.94
DOI 10.35433/pedagogy.4(115).2023.11

MODELING THE ADAPTIVE SYSTEM OF PROFESSIONAL TRAINING OF FUTURE IT SPECIALISTS AS A MEANS OF FORMING PROFESSIONAL COMPETENCE

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In the search for ways to improve the system of professional training of future specialists under the conditions of active changes in society, a significant role, in our opinion, belongs to the idea of an adaptive approach. The modern labor market needs IT specialists of a new generation, able to work in the conditions of the information society, who can quickly adapt to the constantly changing situation in the field of information technologies. However, in higher education, the specifics of new IT professions and requirements for the content of their training are not considered during the training. Therefore, the higher education system faces the urgent task of improving the quality of professional training of future IT specialists. Scientific and theoretical generalizations of the psychological and pedagogical features of training IT specialists and the modeling method were chosen as research methods.

A model of the adaptive system of professional training of future information technology specialists was designed, consisting of a set of four interrelated blocks that ensure its functioning: aim, conceptual-content, adaptive-technological, effective. The development of the model was carried out in 5 stages: selection of the format of the description of the models; goal and task setting; determination of the specifics of the professional activity of IT specialists, selection of knowledge, skills, abilities, personal qualities that correspond to the competency model of the future specialist; selection of corresponding educational resources; management of the educational process. IDEFO modeling methodology was used to fulfill the objectives of the research. The result of the considered process is an increase in the level of professional competence of future information technology specialists. The proposed model can be used as a tool for researching the educational process in higher education institutions in order to improve the quality of professional training of future information technology specialists.

Keywords: *modelling, model, adaptive system, training of future IT specialists, professional competence.*

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МОДЕЛЮВАННЯ АДАПТИВНОЇ СИСТЕМИ ПРОФЕСІЙНОЇ ПІДГОТОВКИ МАЙБУТНІХ ФАХІВЦІВ З ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ ЯК ЗАСІБ ФОРМУВАННЯ ФАХОВОЇ КОМПЕТЕНТНОСТІ

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У пошуку шляхів удосконалення системи професійної підготовки фахівців, за умов активних змін у суспільстві, значна роль, на наш погляд, належить ідеї адаптивного підходу. Сучасний ринок праці потребує ІТ-фахівців нового покоління, здатних працювати в умовах інформаційного суспільства, які швидко адаптуються до постійно змінюваної ситуації в галузі інформаційних технологій. Однак, у вищій школі, під час підготовки випускників технічних напрямів не враховується специфіка нових ІТ-професій та вимог до змісту їх підготовки. Тому перед системою вищої освіти ставиться актуальне завдання підвищення якості професійної підготовки майбутніх ІТ-фахівців. Методами дослідження обрано науково-теоретичні узагальнення психолого-педагогічних особливостей підготовки ІТ-фахівців та метод моделювання.

Була спроектована модель адаптивної системи професійної підготовки майбутніх фахівців з інформаційних технологій, що складається зі сукупності чотирьох взаємопов'язаних блоків, які забезпечують її функціонування: цільового, концептуально-змістового, адаптивно-технологічного, результативного. Розробка моделі здійснювалася у 5 етапів: вибір формату опису моделей; постановка мети та завдань; визначення специфіки професійної діяльності ІТ-фахівців, виділення знань, умінь, навичок, особистісних якостей, що відповідають компетентнісній моделі майбутнього фахівця; добір ресурсів освітнього процесу; управління освітнім процесом. Для створення моделі використовувалася методологія моделювання IDEFO. Результатом розглядуваного процесу є підвищення рівня фахової компетентності майбутніх фахівців з інформаційних технологій. Запропонована модель може бути використана як інструмент дослідження освітнього процесу у ЗВО з метою підвищення якості професійної підготовки майбутніх фахівців з інформаційних технологій.

Ключові слова: моделювання, модель, адаптивна система, підготовка майбутніх фахівців з інформаційних технологій, фахова компетентність.

Introduction of the issue. Socio-economic transformations in society caused the need to change the educational paradigm, which led to the emergence of a number of innovations in pedagogical theory and practice, in particular, in matters of training future specialists, during which the peculiarities of new IT professions and requirements for the content of their training on the part of employers are not fully taken into account. Thus, future IT specialists should not only use theoretical knowledge and practical skills acquired in the process of training, but also strive to master new software products and further deepen the knowledge and skills needed in professional activities. The process of training IT specialists is complex and requires the determination of not only its constituent elements and the relationships between them, but also corresponding interaction in solving tasks aimed at realizing the goals of specialist training. A vector of development has

been formed in educational systems of various levels, which allows to actively adapt to changing socio-economic conditions, satisfying the requests, wishes, and needs of consumers of educational services, customers, and society as a whole. This confirms the relevance of studying the adaptive approach in education, which has specific properties and corresponding adaptive essence in its core. Therefore, there is currently a problem of designing adaptive systems of professional training that will contribute to the integration of future IT specialists in the field of information technologies. One of the universal methods of studying complex processes is modeling.

Current state of the issue. The analysis of scientific sources testified to the existence of prerequisites that allow designing adaptive systems of professional training. Moreover, the theoretical and methodological foundations of adaptive systems of

professional training of higher education seekers (T. Dmytrenko, O. Yeremenko, S. Kopylova; V. Kruhliuk, V. Osadchyi, K. Osadcha, O. Spirin) as well as adaptive educational systems were developed (V. Bondar, T. Desiatov). The structure of adaptive training of higher education seekers is considered by V. Bondar, O. Znanetska, T. Opaliuk, T. Franchuk, I. Shaposhnikova, etc.; development of adaptive learning and testing technologies are investigated by P. Brusylovskyi; peculiarities of training specialists in technical specialties are studied by V. Bykov, V. Kruhliuk, P. Malezhyk, S. Semerikov, etc.

Outline of unresolved issues brought up in the article. However, the theory and practice of professional education lacks sufficient experience in the design and implementation of adaptive systems that contribute to the formation of the professional competence of future information technology specialists, which necessitates the consideration of theoretical approaches to their construction.

Aim of research is to theoretically substantiate and design a model of an adaptive system of professional training of future IT specialists in conditions of digitalization.

Results and discussion. Modeling is widely used as a method of scientific investigation because it allows to carry out quantitative and qualitative analysis of the object under study, as well as to determine its main parameters and ways of improvement and development. We will build an adaptive system based on the modeling methodology.

Modeling in science refers to the process of building, studying, and applying models, which is closely related to such categories as abstraction, analogy, hypothesis, etc. Thus, modeling involves the construction of abstractions, conclusions by analogy, and the formation of scientific hypotheses.

That is, modeling involves the creation of model hierarchies, which allows the actual existing system to be modeled in different aspects and by different means.

According to V. Bykov, pedagogical modeling not only develops the theory of construction and functioning of training and education systems, but also allows to determine essential subsystems, their relationships and properties that affect quality characteristics, allows to form requirements for their components taking into account the achievements of science and practice, in particular ICT methods and tools, progressive psychological and pedagogical approaches, on which open education systems are based [2: 32].

It is important in modeling to preserve the structural and functional correspondence between the model and the modeled object [1: 89].

The main concept of the modeling method is the *model*. Usually, a model is understood as an artificially created object in the form of a scheme, structures, symbolic forms or formulas, which is similar to the object (or phenomenon) being studied, reflects and reproduces in a simple and abstract form the structure of the studied process or phenomenon [3; 5]. The generalization of the interpretations of the concept of "model" given in scientific sources allows us to determine the features characteristic of models: an artificially created object; a structure that reproduces part of reality in a simplified form; a visual representation of the original, a conventional image of an object that reflects real or assumed properties.

In the process of cognition, the model performs the following functions: substitutional, informational, epistemological, formalization-algorithmic, evidential-illustrative [4: 227].

When creating a model of an adaptive professional training system for future information technology specialists, we were guided by the following requirements:

1) The correctness of the model, which is determined by the optimality of the ratio of interacting elements in the model that make up the real object being modeled;

2) It gives a specific description of the basics of system functioning and

corresponds to the real properties and relationships of the elements of the modeled system;

3) Conformity of the model to the level of research, which allows generalizing and conclusions that are verified experimentally.

The model development was based on the following modeling principles:

– integrity – determines the possibility of decomposing the model into subsystems, identifying connections and relationships of its constituent subsystems, which construct the model as a whole;

– purposefulness – conditions a complete, accurate and adequate description of the adaptive system of professional training, which has a specific purpose (goal of functioning);

– dynamism – provides the model with constant improvement and development;

– openness – allows to supplement, transform, modernize, adapt the model without significant restructuring of its structure in the event of a change in the goals or direction of the research.

We believe that the creation of a model of an adaptive system of professional training of future IT specialists in the conditions of digitalization, in accordance with the requirements of the system approach, should be represented by various aspects, in particular:

– morphological aspect (presupposes the definition of the boundaries of the research object as a system, the selection of its elements);

– structural aspect (presupposes the selection of the internal organization of the system and methods, the nature of the connection of elements);

– functional aspect (presupposes consideration of the mechanism of internal functioning of the system, interaction of the system with the external environment);

– genetic aspect (presupposes the analysis of the origin of the system, the process of its formation and development).

The development of the model can be reflected from four positions: what the model contains (components), when the

relevant event will occur (dynamics of the processes reflected in the model), how the educational process should be implemented (didactics), who and with what resources will implement the educational process (management).

The development of the model of the adaptive system of professional training of future IT specialists involved the implementation of the following stages:

1. Selection of the model description format.

IDEFO (Integrated Definition 0–Function Modeling) modeling methodology is used to create a model that reflects the structure and functions of the system, as well as flows of information and material objects [7; 8]. The educational process will be considered as a structure of functional elements, the interaction between which will be depicted by arrows.

2. Setting the goal and objectives (considering the participants of the educational process and the availability/possibility of obtaining resources).

It is assumed that in particular educational institutions in the specific educational conditions the aim of the educational process may be altered, thus modifying the corresponding individual tasks and objectives.

3. Determination of the peculiarities of the professional activity of IT specialists, selection of knowledge, abilities, skills, personal qualities that correspond to the competency model of the future specialist.

At this stage, there is a requirement for continuous monitoring of the labor market, assessment of possible trends and requirements for graduates of higher education institutions. The totality of these requirements can be considered as a social demand to this subsystem of education.

The dynamics of the patterns of the historical development of the system of training of IT specialists, the identification of the relevant current trends and prospects for its development in the future, the need to design an adaptive

system of professional training are being tracked.

4. Resources of the educational process.

Requirements for didactic materials are determined, including special equipment, organization of training classes in a given informational and educational environment; resources necessary for the preparation and conducting of training sessions, independent work of higher education seekers.

5. Management of the educational process.

At this stage, the following aspects are described: who, by what means, and at what moments of time carries out management actions on the process. These activities include directing, controlling and diagnostic activities.

The construction of structural and functional models begins with the top-level context diagram shown in Fig. 1.

The context diagram for modeling the adaptive system of professional training of future IT specialists consists of the main task block, which reflects the essence of the model and the purpose of its construction, as well as interface arcs of four types, which are directed to the main block:

1) Input information (input blocks) – the element from which the process of forming a model of the adaptive system of

professional training of future IT specialists begins (external and internal information sources: students of higher education institutions – future IT specialists, foreign and domestic experience of IT professional training – specialists, requirements of employers, etc.);

2) Management – regulatory and legal support that regulates the professional training of future IT specialists (standards of higher education of Ukraine, international standards and recommendations in the field of information technologies, etc.);

3) The mechanism is the resources involved in professional training (teachers of higher education institutions, educational and methodological support, educational technologies, digital technologies, etc.). Thanks to them, the initial request is transformed into the final result with the use of intermediate information regarding the requirements for the professional training of future IT specialists, the level of formation of professional competence, as well as software tools that allow adapting the educational process;

4) The initial element is the result of the entire process, which must be acquired (increasing the level of professional competence of future IT specialists).

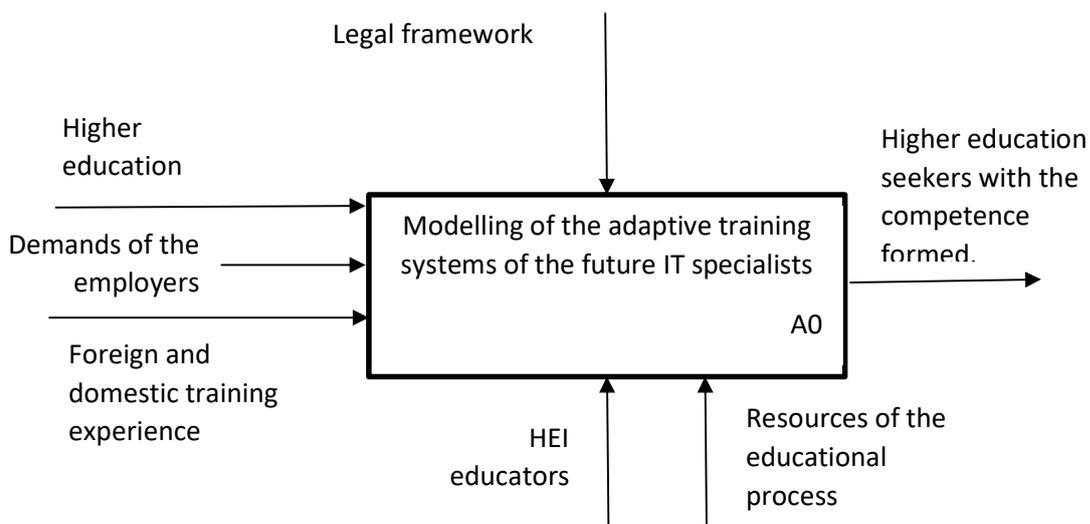


Fig. 1. Contextual diagram of the modeling of the adaptive system of professional training of future IT specialists in (zero level)

The next stage of modeling is the decomposition of the context diagram, which is the process of breaking down the overall process into interconnected components that reflect the formalized sequence of modeling the adaptive system of professional training of future IT specialists. It makes it possible to distinguish functional subsystems, according to which the researched process can consist of the following stages: *determination of the initial level of formation of professional competence; development of an adaptive system of professional training of future IT specialists; formation of professional competence of future IT specialists*. Intermediate results in this case will be information about the existing level of formation of professional competence and the content, forms and methods of professional training of future IT specialists.

By successively revealing the levels of the model in the IDEF0 format, the competence model of the future information technology specialist and the model of the adaptive system of professional training (Fig. 2) were designed, by which we understand a complete system consisting of aim (target), conceptual-content, adaptive-technological and effective blocks, interconnected with each other.

The **aim (target) block** of the model determines the priority direction of the development of the adaptive system of professional training of future IT specialists, determined by the social demand and modernization of the education system. It is focused on the description of the scientific and theoretical foundations of the formation of professional competence of future IT specialists. This block is classically represented by the requirements of the social demand: a set of requirements of society and the digital economy for the training of higher education seekers.

Within the aim (target) block, we identified and formulated a goal that consists in forming the professional competence of future IT specialists during their studies at higher education institutions. In our opinion, the set goal should be specified by considering the requirements of the standards of higher

education of Ukraine, as well as the requirements of international projects and standards in the field of information technologies.

The target unit is a system-forming factor of an adaptive system of vocational training and determines its main components: the content of training, methods, forms and means, applied technologies and the resulting training results.

The conceptual-content block of the adaptive system is determined by the aim (target) block and contains conceptual and substantive interrelated components. The conceptual component is focused on the description of scientific and theoretical foundations for the organization of the process of formation of professional competence of future IT specialists. Within its limits, methodological approaches and principles that form the core of the concept of an adaptive system of professional training of future information technology specialists are singled out.

The initial methodological provisions, which conceptually ensure the implementation of an adaptive system of professional training of future information technology specialists in the conditions of digitalization, are systemic, synergistic, environmental, informational, person-oriented, competence-based, activity-based, adaptive, contextual, and technological approaches, which are interconnected and complementary each other. The essential characteristics of methodological approaches are disclosed in [6].

Methodological approaches determined a set of pedagogical principles for the organization of the researched process, which includes didactic (systematic, scientific, fundamentalization, accessibility, integrity, manageability, humane and personal orientation of professional training); personal-oriented (choice of an individual educational trajectory, goal-setting and effectiveness, motivational and intellectual activity, communicativeness, educational reflection) and technological (information security, adaptability, cyclical learning, microportioning, relevance and automation of monitoring).

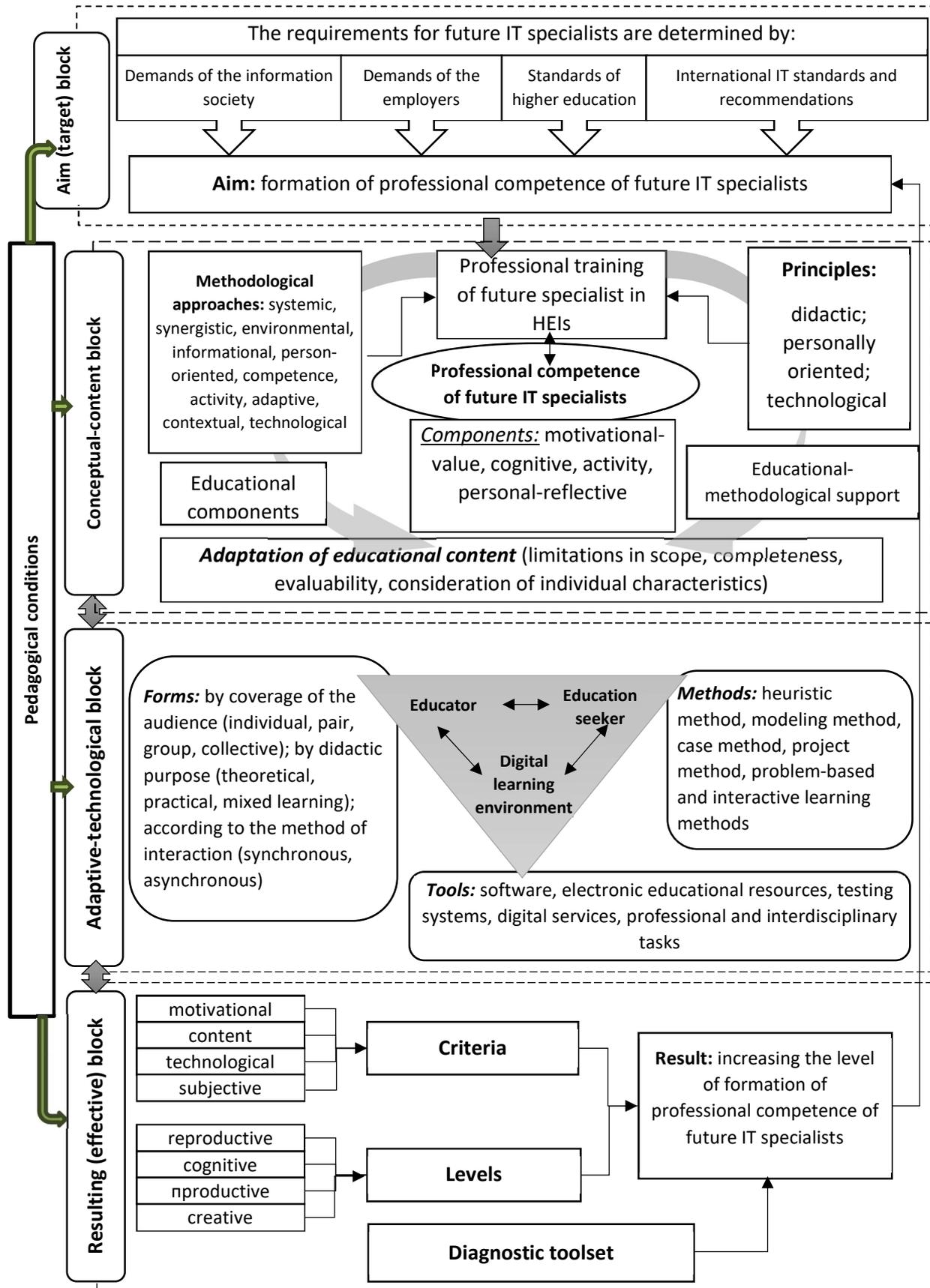


Fig. 2. A model of the adaptive system of professional training of future IT specialists in conditions of digitalization

The selected approaches and principles act as requirements for the content of the professional training of future information technology specialists and the formation of professional competence, which is reflected in the methodology of its implementation (educational programs, training programs, manuals, methodological recommendations, etc.).

The content (substantive) component is determined by the subject content of educational disciplines and contains components of the professional competence of future IT specialists (motivational-value, cognitive, activity, personal-reflective). Educational content, its form and content should be oriented to the individual characteristics of the students of education and "adjust" to the level of their educational results.

Relying on the technology of microlearning, when creating content, we focused on its limitations in terms of volume, completeness of information and evaluability – the possibility of monitoring its assimilation. This approach will make it possible to create educational content in the form of independent small fragments that can be used repeatedly during the development of new educational programs or adaptation to the characteristics of a specific student.

The adaptive-technological block provides an optimal combination of methods, forms and means of learning in the adaptive system of professional training of future IT specialists in the conditions of digitalization and is interconnected with the conceptual-content block. The determination of forms, methods and means of education is carried out considering the individual characteristics of higher education applicants and the principles of adaptive learning, integration of offline and online learning.

The professional competence of future IT specialists is formed thanks to the following forms of organization of the educational process: by the coverage of the audience (individual, pair, group, collective); by didactic purpose (theoretical, practical, mixed learning);

according to the method of interaction (synchronous, asynchronous).

A variety of methods can be used to form the professional and personal qualities of future IT specialists. However, in order to form a certain quality, it is necessary to use basic methods and their choice is determined by the characteristics of the subjects of the educational process.

The research focuses on active learning methods, which will contribute to the formation of cognitive motivation to learn the educational material. Taking into account the specifics of the activities of IT specialists, in particular their participation in project development, it is important to develop teamwork skills using appropriate methods. The organization of team project activities in accordance with the iterative model of the software life cycle allows you to organize the implementation of group projects for the application of acquired knowledge and skills in professional activities.

We also distinguish the heuristic method, modeling method, case method, problem-based and interactive learning methods. A characteristic feature of heuristic learning is the creation of educational products by students and the construction of individual educational trajectories in each of the educational areas.

We note that the implementation of the listed forms and methods of organizing the educational process is most effective when using system, applications and instrumental software, multimedia materials, means of organizing electronic learning, simulators, communicative means of learning, testing systems, etc.

The functioning of the adaptive system of professional training of future IT specialists is ensured by adaptive technologies for the organization of the educational process, the use of which is closely related to the adaptation to the individual characteristics of students of higher education, which have a significant impact on educational activities. Thus, the flexibility of these technologies is of particular importance, as well as their variability, patterns of

actions, certain factors, which include objective complexity and individual difficulties.

The didactic design of adaptive technologies is carried out by adapting the educational process (goals, content, methods, diagnostics, structure of the content of the modules of educational components of professional training) to the individual characteristics of the students in accordance with the tasks of holistic development of the professional competence of the future specialist.

The resulting (effective) block of the structural-functional model of the adaptive system of professional training of future IT specialists is aimed at the implementation of functions of a diagnostic, corrective and reflective nature.

It includes the result of the considered process (increasing the level of formation of professional competence of future IT specialists), as well as a system of criteria for determining the level of its formation. Taking into account the selected components of the professional competence of the future IT specialist (motivational-value, cognitive, activity, personal-reflective), the following four criteria were determined: 1) motivational (professional motives, educational and cognitive motives, value attitude to the processes of self-improvement, self-development); 2) content (completeness, depth, efficiency, flexibility and awareness of knowledge acquisition in the field of information technologies); 3) technological (formation of analytical, design, technological and communication skills); 4) subjective (degree of development of personal qualities, objectivity of self-assessment, own knowledge, abilities, skills, level of development, ability to adjust one's own activities in accordance with the assessment results).

The process of forming the professional competence of future IT specialists is considered as a transition from one level to another, more complex and qualitatively different: reproductive (initial) → conscious (medium) → productive (sufficient) → creative (high).

The block includes a diagnostic toolkit for evaluating the effectiveness of the adaptive system of professional training of future IT specialists in the conditions of digitalization, which will allow analyzing the levels of formation of professional competence and identifying the dynamics of the training process.

Also, feedback is included in the structure of the adaptive system model, which allows to adjust educational goals based on the performance-based block.

Thus, the result of the substantiation of the model of the adaptive system of professional training of future IT specialists is the development of its constituent blocks – aim (target), conceptual-content, adaptive-technological, resulting (effective).

The adaptive system of professional training of future information technology specialists, like any system, functions and develops subject to certain conditions. Based on the analysis and assessment of the influence of certain aspects, components, properties of the object under study on the effectiveness of its functioning and development, a complex of pedagogical conditions is identified.

We identify pedagogical conditions as a set of mandatory external requirements, compliance with which will ensure the achievement of an optimal result. In the context of our research, such an optimal result is the professional competence of future specialists in information technologies, which is a criterion of efficiency and optimality in identifying and developing a system of pedagogical conditions for its formation.

In order to identify pedagogical conditions, the educational environment for the implementation of the system of professional training of future IT specialists was considered and correlated with the necessary measures to ensure the implementation of the developed model. The starting point for determining pedagogical conditions are the components of the analyzed parameter namely: increasing the professional competence of future information technology specialists.

During the study, we identified the following pedagogical conditions for the implementation of an adaptive system of professional training of future information technology specialists in the conditions of digitalization:

1. *Organization of the educational process considering the need to form professional value orientations and the need for self-development of the future information technology specialist.*

The formation of professional value orientations of an individual is possible with the use of active learning methods that allow students to engage in activities that have features of future professional activity; rely on the creative activity of the higher education seekers, which is necessary for the formation of values that stimulate the self-development and self-actualization of an individual; to have a competitive and game element in conducting classes, which is also necessary for the formation of values of social recognition.

2. *Individualization of cognitive activity of higher education seekers (choice of study content, method, and pace of work.*

Cognitive processes occur differently in each individual, so the results of training differ in each case. As a degree of increasing the efficiency of independent work, it is necessary to provide the student with the choice of the optimal method and pace of mastering the curriculum of the discipline. To manage educational and cognitive activities, individualization of the educational process is necessary: the possibility of choosing modules; individualization of the trajectory of assimilation of educational material. The content of the future IT specialist's education must be chosen taking into account the dynamically changing flow of modern knowledge. The selection of educational learning technologies is based on the application of various forms and types of work of applicants based on the use of educational technologies and objective methods of monitoring and evaluation activities.

3. *Creation and development of the information and educational environment of higher education institutions.*

The creation of an information and educational environment is a basic condition that ensures the effectiveness of the communication activities of teachers and higher education seekers and allows the transition to educational information technology. The environment is represented by a system-unifying space with the placement of computer equipment and networks (local, global), as well as educational and informational resources that realize the possibilities of pedagogical and digital technologies, creating a personal environment for individualizing the professional training of future IT specialists.

Conclusions and research perspectives. Summarizing the results of our research, it can be stated that:

- in the designed model of the adaptive system of professional training of future IT specialists, all components of this process are reflected, which allows to resolve the existing contradiction between the need for the formation of professional competence of those seeking higher education and the insufficient development of the theoretical justification of this process;

- the blocks included in the model (aim (target), conceptual-content, adaptive-technological, resulting (effective)) are interconnected and aimed at achieving the planned result - increasing the level of professional competence of future information technology specialists;

- the formation of professional competence of future IT specialists using the model of an adaptive system of their training is provided by a set of pedagogical conditions that purposefully create an educational process using modern digital technologies.

The proposed model can be the basis for the development of educational programs, improvement of training forms and methods, which will allow bringing the educational process closer to industrial conditions.

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Received: November 03, 2023

Accepted: November 30, 2023