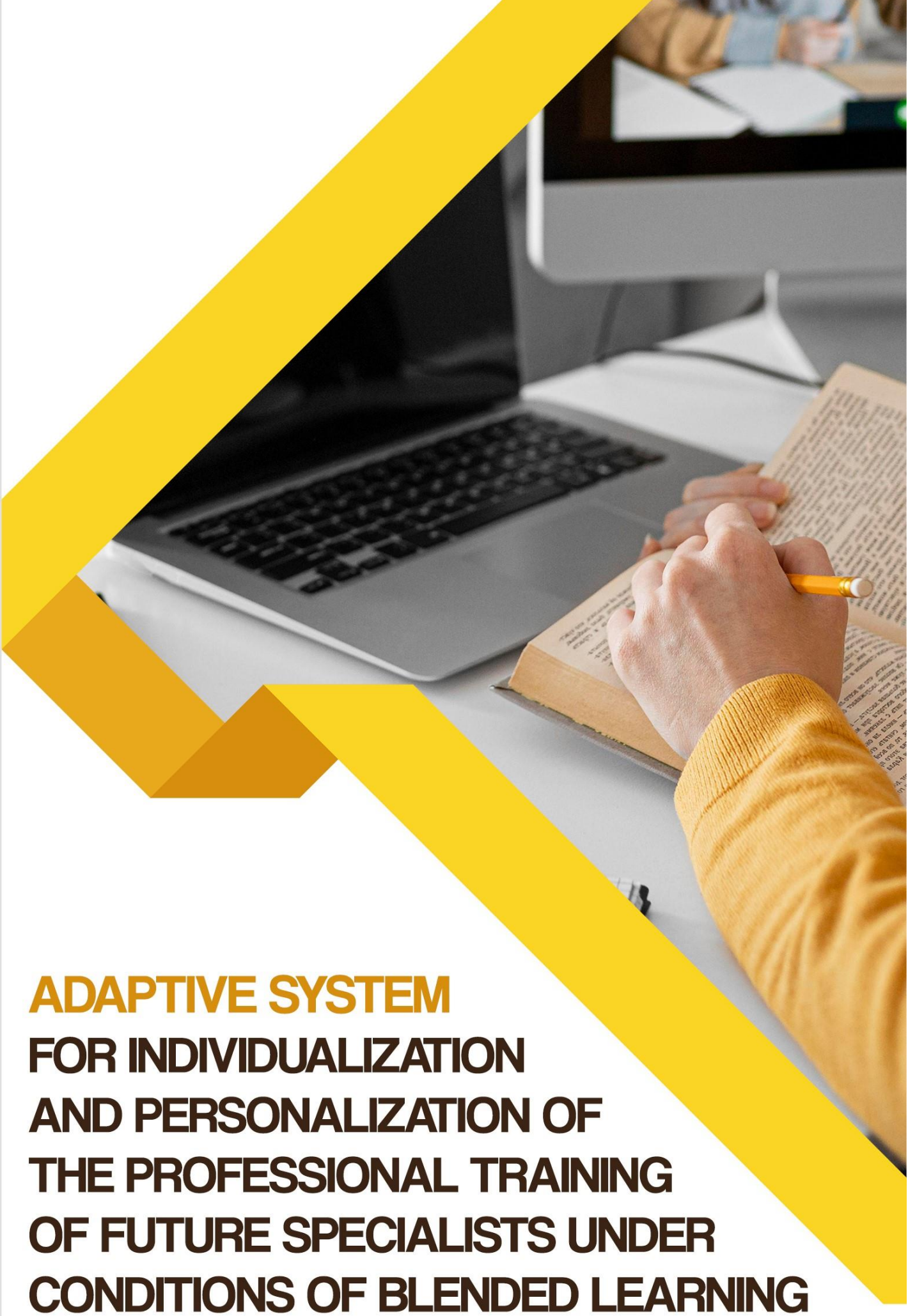
ADAPTIVE SYSTEM FOR INDIVIDUALIZATION AND PERSONALIZATION OF THE PROFESSIONAL TRAINING OF FUTURE SPECIALISTS UNDER CONDITIONS OF BLENDED LEARNING



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ADAPTIVE SYSTEM FOR INDIVIDUALIZATION AND PERSONALIZATION OF THE PROFESSIONAL TRAINING OF FUTURE SPECIALISTS UNDER CONDITIONS OF BLENDED LEARNING

Monograph

Edited by Viacheslav Osadchyi

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The monograph presents the results of a collective study within the framework of the scientific research project "Adaptive system for individualization and personalization of the professional training of future specialists under conditions of blended learning" (state registration number: 0120U101970). The most important results include the concept and model of the specified system and practical recommendations for building an educational process based on it.

It is intended for scientific, scientific-pedagogical, managerial workers, doctoral students, graduate students and master's students who deal with theoretical and practical problems of implementing adaptive learning systems in educational practice.

The authors bear full responsible for the text, data, quotations, and illustrations

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CONTENT

INTRODUCTION

Higher education, as a leading channel for the transmission of scientific knowledge, is today under strong pressure from the society, which is characterized by demands for its improvement, quality improvement, approximation to the real practice of social life, etc. This is related, in particular, to the formation of open societies of knowledge, post-classical science and open education. The imperatives of education development today are interdisciplinarity and transdisciplinarity, integrity, dialogization, anthropocentricity, individual freedom, orientation to the needs of society and production, attention to complex systems, accessibility of education for broad sections of the population, continuity of education, etc. These guidelines are reflected in the implementation of student-centered and competency-based approaches, individual educational trajectories, consideration of labour market requirements, etc. At the same time, they somehow conflict with the traditional educational system, built on the foundations of epistemological knowledge, and create new risks for it.

The analysis of scientific studies has shown that the problem of implementing an adaptive system of professional training of future specialists as a complete pedagogical system, which includes not only the latest information and communication technologies, but also the conceptual foundations and organizational conditions of its functioning, remains outside the attention of researchers. The analysis of existing adaptive learning systems has proved that in most cases these developments are either distributed on a commercial basis, or have limited functionality, or do not have the means to integrate them into the educational process of specific educational institutions.

Therefore, the relevance of the study is determined by the need to overcome the contradictions between: the high level of professional demand for qualified specialists and the unreadiness of the higher education system of Ukraine to meet these needs in full;

– the urgent need of the economy and society for responsible, creative and critical-thinking specialists who are able to independently and quickly make professional decisions, and the predominance of traditional,

knowledge-based forms and methods of professional training in higher education;

– society's demand for the application of the individual approach to training and education of specialists and the unwillingness of scientific and pedagogical workers to implement it;

– wide possibilities of information and communication technologies, in particular distance ones, and insufficient readiness of scientific and pedagogical workers for their use in the educational process.

Learning management systems and their use in blended learning enable the implementation of the individual approach, but to an incomplete extent. That is why the current direction of research is the improvement of existing learning management systems and the creation of adaptive systems of professional training of future specialists based on them.

The research project of the Department of Informatics and Cybernetics of Bogdan Khmelnitsky Melitopol state pedagogical university "Adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning" (state registration number: 0120U101970) is aimed at solving this task. Its results are presented in the monograph. Part of the monograph authored by K. P. Osadcha is funded by the Federal Ministry of Education and Research (BMBF) and the Baden-Württemberg Ministry of Science as part of the Excellence Strategy of the German Federal and State Governments.

CHAPTER 1.
THEORETICAL AND METHODOLOGICAL PRINCIPLES OF IMPLEMENTATION OF BLENDED AND ADAPTIVE LEARNING IN INSTITUTIONS OF HIGHER EDUCATION

1.1. Research terminological apparatus

The processes currently taking place in society determine new socio-humanitarian challenges facing higher education institutions. In particular, the requirements for ensuring access to quality education, taking into account the characteristic features of certain groups of education seekers, etc., are being strengthened.

Currently, there is a qualitative transition of the higher education system to a competency-based approach based on a paradigm that involves the formation of an individual educational trajectory for each student. In particular, during the round table on the topic "Educational policy under the conditions of the information society", held on 05/24/2016 by the Committee on Science and Education and the Committee on Informatization and Communication together with the Association of Information Technology Enterprises of Ukraine, special attention was focused on that information and communication technologies allow an individual approach and development of each individual in accordance with individual learning styles. In this way, it is possible to develop the talents of each individual, and not to teach everyone the same. The orientation of the educational process towards individualization and personalization of education is recorded in the Law of Ukraine "On Education" [190], which provides an interpretation of the concepts of "individual educational trajectory", "individual development program" and "individual curriculum", etc.

In the modern educational space, e-learning is widespread due to the use of information, computing and telecommunication technologies, as well as a wide range of distance technologies. The rapid development of information and communication technologies contributes to the search and application of new approaches that allow diversifying the process of student learning.

Among the innovative educational technologies that can improve the professional training of future specialists in higher education, it is worth highlighting blended learning, adaptive, individualized and personalized electronic learning, etc. However, despite scientific achievements in this area [107; 148; 175], the problems of individualization and personalization of e-learning, creating adaptive learning systems, expanding the toolkit of learning management systems used in educational institutions, etc., remain insufficiently developed.

An individual educational trajectory is a personal way of realizing the personal potential of each student in education. The terms "varied training", "personalized training", etc. are used as synonyms. The application of an individual learning trajectory, as well as its differences from an individual educational route and an individual educational program, is discussed in the study of K. P. Osadcha, where an individual educational trajectory is determined based on what experience was accumulated, what was studied, done, chosen, which was significant and interesting for the student [193, p. 33].

The concept of blended learning, known since the 60s of the last century [26, p. 3], is not new and is widely used in the world. Information and communication technologies used to support blended learning have undergone significant changes over the past decade, so they require understanding and methodological justification for appropriate use in the process of updated blended learning in higher education institutions of Ukraine.

The demands of society regarding the training of specialists in institutions of higher education and the conclusions that were made during the use of distance technologies during the coronavirus pandemic [195], actualize the issue of using distance in the structure of blended learning in the professional training of future specialists.

In the scientific literature, the term **blended learning** means a learning method that combines elements of traditional and electronic learning (distance learning, mobile learning) [261]. In blended learning, from 30% to 80% of the academic learning process is transferred from classrooms to the virtual space of the Internet, where students can choose the path, time and pace of learning. Institutions of higher education independently create

conditions for blended learning using various platforms, in particular: learning management system Moodle, massive open online courses (Coursera, Prometeus, etc.), mobile educational applications, etc.

The essence of blended learning was highlighted in their works by leading Ukrainian scientists, in particular: K. L. Bugaichuk, O. V. Korotun, V. M. Kuharenko, M. M. Prokopchuk, G. V. Tkachuk, and others. Without delving into the genesis of the concept, we note that "blended learning" should be understood as a kind of hybrid methodology, when there is a combination of traditional (offline learning, in classrooms, face-to-face), online and independent learning [229]. It is not just the use of modern information and interactive technologies in addition to the traditional ones, but a qualitatively new approach to learning. In foreign publications, the term "hybrid training" is found, which is considered synonymous with the concept of "blended learning" and is understood as combining face-to-face training and online training, which is the most promising approach for higher education [168]. V. M. Kukharenko and others. distinguish between these concepts as follows: blended learning emphasizes a purely mechanical approach to mixing different forms of learning, while hybrid is a combination of new, advanced, using the capabilities of IT technology with old technology and the formation of a new approach (innovation), taking into account the known capabilities of the old technologies [149, p. 14].

In a narrow sense, K. L. Bugaichuk [41] suggests that blended learning should be understood as a purposeful process of acquiring knowledge, skills, and abilities, which is carried out by educational institutions of various types within the framework of formal education, part of which is implemented in a remote mode with the help of information and communication technologies and technical teaching aids, which are used for storage and delivery of educational material, implementation of control measures, organization of interaction between subjects of the educational process (consultations, discussions) and during which self-control of the pupil (student) is carried out in terms of time, place, routes and pace of learning. And in a broad sense, the scientist defines it as various options for combining forms and methods of organizing formal, informal, informal learning, as well as self-learning, which are carried out to achieve the person's predetermined

educational goals while maintaining the mechanism of control over time, place, routes and pace of learning. So, in the Ukrainian scientific opinion, a clear definition of the concept of "blended learning" is given.

In particular, in a study [168] based on a comparison of blended learning, face-to-face learning, and online learning, it was concluded that blended learning is more effective than online learning. In [97], it is shown that the strategy of blended learning is satisfactory, provided that interactive methods are used, focused on students, it is effective both in the process of teaching and learning, and in the current and final assessment.

Distance learning technologies as a component of blended learning were studied by V. V. Oliynyk, K. P. Osadcha, V. V. Osadchyi, M. M. Nazar, O. M. Samoilenko, B. I. Shunevich, and others. The issue of introduction and application of distance and blended learning in professional education is highlighted in the works of R. S. Gurevich, O. A. Kulinych, I. Marynchenko, V. Yagupov, and others. Despite the wide coverage of theoretical, methodological and practical aspects of blended learning, the problems of its application in professional education have received little attention.

The advantages of distance learning include the availability of courses and their modular construction. Each student can choose the appropriate course as needed. The next criterion is the practicality of training (the use of methods of adapting training to the needs of the student). The third advantage includes low training costs (no trips to training, sessions). The fourth advantage is mobility. And, finally, the choice of study time (the student himself chooses a time convenient for him to study) [189].

Conclusions about the popularity and use of the terms "blended learning" (blended learning) and "hybrid learning" (hybrid learning) in English and Ukrainian during the last 5 years can be made based on the indicators of the Google Trends service (Fig. 1.1, 1.2).

So, according to Google Trends, neither the English-language term "hybrid learning" nor the Ukrainian-language "hybrid learning" is widespread in Ukraine. With this in mind, we focused the content analysis of scientific publications over the last 5 years on the application of blended learning in professional education on the term "blended learning".

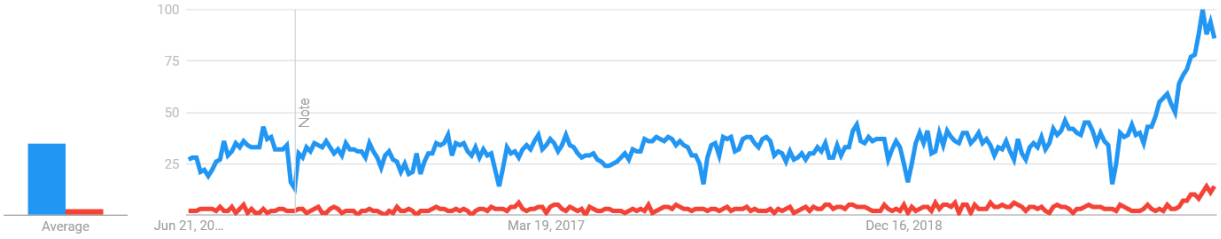

Fig. 1.1. Popularity of the search terms "blended learning" and "hybrid learning" on the Internet

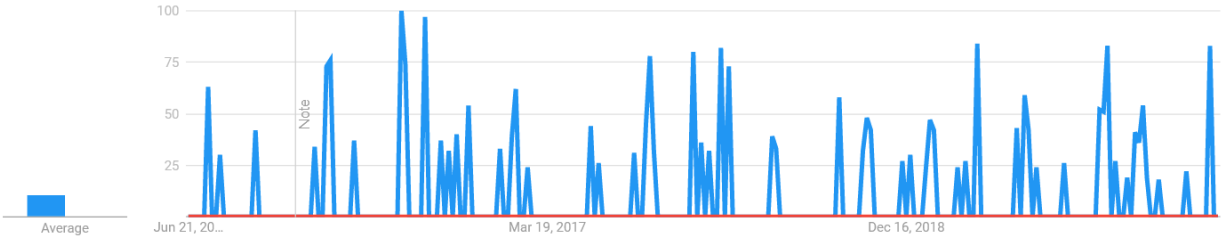

Fig. 1.2. The popularity of the search terms "blended learning" and "hybrid learning" on the Internet

As a result of a search in the Google Scholar system with the search query "blended learning" and "professional education" 56 results were obtained, among which 8 articles and one collective monograph (8 articles) were selected. The analysis of these scientific publications made it possible to determine their number by year: 2016 – 3, 2017 – 1, 2018 – 11, 2019 – 0, 2020 – 1. Based on the analysis of the content of the articles, the main ideas regarding blended learning in professional education were determined (Table 1.1).

From the analyzed scientific works, the opinion of O. V. Bazeliuk is important, that "blended learning in vocational education is proposed to be understood as a harmonious combination of distance learning (for mastering theoretical knowledge) and real practical activities of students", which will provide "an opportunity to use the advantages of distance and traditional education, as well as to avoid the shortcomings that are inherent in each of the specified forms" [19, p. 106].

Table 1.1. Basic ideas about blended learning in professional education

Author	Leading idea
M. Artyushina [9]	The practice of training future teachers of professional training proves the importance of developing their information and digital competence through the study of special disciplines of informative orientation in the mode of blended learning with in-depth use of IT in the educational process of all disciplines of professional training.
O. V. Bazeliuk [22]	Modern information technologies present wide opportunities for the automated implementation of information and analytical functions and provide the possibility of creating a single information field of professional education, which is a complex of interconnected and mutually conditioned structured and unstructured information arrays.
O. V. Bazeliuk [21]	The powerful capabilities of cloud services can be implemented in the educational process of ZP(PT)O as an auxiliary tool for distance learning of all specified types.
O. V. Bazeliuk [19]	Blended learning allows you to take advantage of the flexibility and convenience of a distance course and the advantages of a traditional classroom.
O. V. Bazeliuk [20]	Logically structured system tools, specialized hardware and software learning complexes (LMS), in particular Moodle (moodle.org), can provide high-quality training of qualified workers.
R. M. Horbatiuk, M. M. Ozhga [100]	The application of elements of the planning of the educational process in the conditions of the application of blended learning technology (analysis of the project, target group, content and financial analysis) and the introduction of the model of blended learning, based on the use of an electronic educational resource as an equal subject of learning, have an effective influence on the formation of professional competences of future engineers-pedagogues in the field of computer technologies.
M. Yu. Kademiya [115]	The organization and implementation of the educational process in the conditions of the implementation of a virtual university (mobile, pervasive, "inverted" and blended learning), in particular, a virtual department that reproduces the educational, scientific and educational activities of the department in the information space of the university, helps to solve pedagogical and methodological problems in training of information technology specialists.

Author	Leading idea
A. A. Kalenskyi [119]	It is important that the internal IT structure of the Higher Education Institution provides an opportunity for training future vocational education specialists at any time, anywhere and from any device.
A. P. Kobysia [129]	The organization of blended learning of students based on an informational educational environment using electronic educational and methodological complexes of disciplines, the use of modern information technologies of interactive learning, the use of computer-oriented technologies for structuring educational information and presenting it in various formats, allows to qualitatively assess the work of students and the level their competence, activate cognitive interests due to the reflection of their personal activity, self-control and self-checking of achievements.
O. A. Kulinych [150]	The introduction of blended learning in institutions of professional (vocational and technical) education (VET(PT)O) depends on a sufficiently developed level of information competence of teachers, which will be helped by the creation of a platform for approving models of blended learning in VET(PT)O.
L. A. Maiboroda [161]	Distance learning differs from traditional forms of learning in high dynamism, which is associated with a flexible choice of educational elements, a significant amount of independent work, a variety of forms of educational and methodological support, which makes it possible to increase the efficiency of educational processes in professional education.
I. Marynchenko [165]	Digital technologies (synchronous and asynchronous learning, mobile learning, "cloud" learning, blended learning) are effective for creating sufficient conditions for the continuous formation and development of digital competence of future teachers of professional education in the artistic profile.
L. M. Petrenko [212]	The basis of the development of pedagogical technologies for distance professional learning in vocational education and training should be the idea of transforming the generally accepted ideas about the goals and objectives of modern education, the implementation of which should take place on the basis of state policy in the field of education and the principles of educational activity.

Author	Leading idea
O. M. Spirin [266]	The study of fundamental and applied problems of the use of ICT in education, in particular in professional (vocational-technical) will make it possible to modernize and optimize the training of workers for the domestic labor market, the shortage of which is becoming more and more noticeable for production and the service sector.
O. Shamralyuk [255]	The introduction of blended learning into the system of work of the regional methodical service is an important condition for raising the level of technological culture of the masters of industrial training of the agrarian profile and allows to build individual educational routes for each teacher, to effectively use the tools of information and communication technologies, to optimally combine methods, means and technologies of training in postgraduate education of masters of industrial training, as well as update the informational and educational environment of professional education.
V. Yagupov [323]	Subjectivity as the main determinant in blended and distance learning should be applied by teachers in professional education.

Personalized training is considered as a generalized term associated with such educational concepts as: adaptive training, differentiated training, competency-based education, educational analytics [95]. Personalized learning means that the educational process is optimized for the needs of each student. The purpose of study, study approaches and study content may differ depending on the needs of the student. According to their trajectory, they attend and study lectures, laboratory and practical classes [304].

Personalized learning means adapting education to the current situation, characteristics and needs of students to help them achieve the best possible progress and learning outcomes. Personalized learning can appear at various levels of education, including the personalization of curricula, courses, learning materials, learning activities, and more. Thanks to personalized learning, each student receives an education that meets his/her individual characteristics and needs, and learns in the most suitable way for him / her [92].

To understand the concept of "personalization", Kinshuk gives the following example. “Suppose two students are learning some accounting concept online. One student comes from a family that runs a small business. The other is from a family of farmers. Personalizing learning for both students would mean understanding their backgrounds and providing them with practical cases they may have encountered before. For a student with commercial experience, an example from the company's activities will be more familiar. Whereas for a student who has experience in farming, a case study related to farming will provide a better introduction" [126, p. 5].

Therefore, personalized training is "training programs developed taking into account the interests, experience, desired methods and pace of training of a specific person" [211, p. 4]. Depending on the technologies and teaching methods used, the following forms of personalized training are distinguished:

- expanding the student's autonomy: giving the student independence and freedom in choosing a set of disciplines for in-depth study;
- self-education: full freedom and responsibility of the student in choosing educational tasks, content and didactic tools to achieve the educational goal. The educational institution performs service functions, for example, providing infrastructure for social and collaborative learning;
- differentiated training: division of students into groups / categories, for each of which, taking into account the interests, abilities, motivation of the participants, specific methods and methods of educational work are selected;
- adaptive learning: in real time, computer technologies adapt educational material to the needs of students [211, p. 4].

According to the conclusion of I. O. Lytsenko, the process of personalization of education contains three components:

1) individualized: implements the learning process itself, aimed at identifying and developing individual abilities of those who study;

2) interpersonal: implements the learning process in which the individual seeks to develop and expand connections with other individuals;

3) meta-individualized: characterizes the learning process aimed at the desire of individuals to present their features in each other, to contribute to the development of the individuality of another,

to the development of communities that arise in the process of educational activity [160, p. 398-399].

So, the essence of personalized training is that the course material is divided into portions, each of which contains information: examples and problems, questions for self-testing, as well as the necessary methodological instructions for completing the tasks. The student studies the material independently and, when he believes that he has mastered it perfectly, passes the test. Permission to move on to studying the next part of the educational material is possible only after receiving a high or sufficient grade for the previous part.

Personalized learning systems help students set their own learning goals, manage their learning, manage content and process, communicate with others in the learning process, thus achieving learning goals. These systems can consist of one or more subsystems, which, in turn, can be built on a software application or on web services [107].

Based on the analysis of research by domestic scientists, we understand the organization of the educational process by using methods and techniques of education taking into account the individual characteristics of a group of students who are similar in a certain set of characteristics [215].

Individualized training involves dosing the amount of educational material in accordance with the abilities of students with scientific or applied goals, with the introduction of a multi-level system of training specialists. One of the means of individualization is a variety of e-learning environments, which allow you to build a system of blended learning with a combination of elements of classroom classes and distance learning.

According to B. Bray and K. McCluskey, the difference between personalization, differentiation and individualization of learning is that the first approach is student-oriented, and the second and third are teacher-oriented. The researchers offered a comparative characterization of these concepts by examining them according to the following main aspects:

1) What does teaching and learning look like when related to these terms?
2) How are the needs of learners determined?
3) How do students participate in their learning?
4) How are goals determined for students?

5) How do students support their learning and other students?
6) How is the significance of training determined?
7) What assessment methods are used? [37].

Adaptive learning in institutions of higher education is the subject of investigations by many Ukrainians (V. Bondar, O. Kanishcheva, M. Kolyada, T. Lendyuk, I. Lyutenko, T. Opaliuk, V. Pishvanova, T. Franchuk, I. Shaposhnikova, etc.) scientists.

However, according to the authors of the monograph [1], adaptive learning in higher education institutions is social unclaimed Participation in it requires students to adapt to unusual learning conditions, types of activities, forms of communication, which leads to a conflict with existing stereotypes of activity [1, p. 13]. In our opinion, this fully applies to teachers, who are faced with the task of ensuring their own and student adaptation to new circumstances.

Adaptive learning involves the mutual influence of the individual on the educational, social, moral and ethical environment, as well as the influence of external and internal factors on the individual [35, p. 37]. It is a technological pedagogical system of forms and methods that promotes effective individual learning, and the combination of this technology with the capabilities of modern information and communication technologies has significant potential for education.

As Kinshuk emphasizes, adaptability in the teaching process means constantly considering the impact of learning approaches on students and changing different aspects of learning to improve the educational process. In online educational environments, the analysis of the learning processes of individual students and the introduction of necessary changes occurs automatically. For example, the environment can recommend a student who has not demonstrated a sufficient level of competence to re-pass the relevant educational unit before moving on to the next one [126, p. 4-5].

An educational environment can be considered adaptive if it has the following capabilities: control of user activity; its interpretation based on specific models; determine the requirements and needs of users based on the interpretation of their activities and adequately represent them in the form of models; facilitate the learning process taking into account the available information [207, p. 182].

The concepts of adaptability and personalization are closely related. As Kinshuk notes, “Adaptability and personalization are, in a sense, two sides of the same coin. Adaptability can be considered as a perspective of the development of the educational environment, and personalization takes into account the individual perspectives of the student. Ultimately, both goals aim to improve the learning of individual students by increasing their efficiency, effectiveness, and satisfaction. These three aspects are not always in sync with each other. For example, increasing efficiency may require focusing only on important concepts, but this approach can affect the effectiveness of the learning process and even lead to a decrease in satisfaction [126, p. 5].

A modern educational trend is the implementation of personalized adaptive learning, which combines the main elements of personalized and adaptive learning: individual characteristics, individual effectiveness, personal development and adaptive adjustment. The first three represent three personalized levels of personalized adaptive learning. The fourth indicates the adaptation of the teaching strategy to achieve personalized levels. Like adaptive learning, this strategy is inseparable from the use of information, communication and digital technologies. Therefore, personalized adaptive learning can be defined as an effective pedagogical approach that relies on the use of technology and can adaptively adjust teaching strategies based on real-time monitoring (thanks to intelligent technologies) of differences and changes in individual characteristics, individual effectiveness and personal development [210, p. 6].

So, based on the analysis of psychological and pedagogical literature, we have characterized the main concepts (individual educational trajectory, blended learning, distance learning, personalized learning, individualized learning, adaptive learning), which are the basis for further development of the concept of an adaptive system for the individualization and personalization of professional training of future specialists under conditions of blended learning.

1.2. Adaptive and personalized learning using information and communication technologies as a subject of scientific research

Lifelong learning is one of the defining concepts of social development. It covers all educational activities of a person, carried out throughout life, aimed at improving knowledge, abilities, skills, competences and / or qualifications, and is carried out on the basis of personal, social and / or professional reasons [289, p. 171]. Professional development of adults is important within its limits, which is considered as "a purposeful process of formation, actualization and increase of professional qualities of adults and professional and professional growth, which is carried out in accordance with the complexity of professional tasks and functions and is conditioned by the need to increase the efficiency of professional activity" [3, p. 79].

Professional development of adults is now closely related to digital learning, which includes distance and blended learning, video tutorials, learning management systems (LMS), massive open online courses (MOOC), adaptive learning systems, virtual and augmented reality technologies etc. forms, technologies, means. In their unity, they provide unlimited opportunities for the professional development of an individual, but they also complicate it, requiring a balanced and responsible approach. In this connection, a number of tasks arise, in particular, to help an adult to form an individual educational trajectory and to choose means that will contribute to the achievement of educational goals, to create conditions for personalized and adaptive learning.

Increasing attention to a person-oriented approach in education, the wide application of information and communication technologies in formal and informal education has led to the activation of research on the problems of individualization and personalization of education, the results of which are reflected in numerous scientific publications. In view of this, it is important to study the current state of the mentioned problem through a review of literary sources. This is a generally accepted method of preliminary analysis within any scientific research, so there are currently a sufficient number of articles that provide the results of the analysis of publications devoted to various aspects of adaptive and personalized learning.

As indicated by M. Turčáni and Z. Balogh, personalized learning recognizes student diversity, cognitive and physical differences, and overall individuality. It includes different styles and approaches to learning: from educational content-oriented to supporting students who communicate, discuss, collaborate [300, p. 47-48].

The results of a meta-analysis of studies devoted to adaptive educational hypermedia (AEH) with an emphasis on learning styles are given in [5]. The authors selected publications from 2000 to 2011 in several electronic databases: Ulrich, ISI Web of Knowledge, EBSCOhost Web, SpringerLink, ERIC, Google Scholar, etc. Various keywords and phrases were used for the purpose of the research, for example: "adaptive / adapted e-learning", "adaptation", "personalized e-learning", "learning styles". The researchers selected 70 articles of such types as: peer-reviewed articles, full-text materials of international conferences, symposia and seminars, dissertations in English. These posts were classified into several categories: Post Type, Purpose, Learning Style Model, Student Modeling, Modeling Tool, Participants, and more. As a result, they defined some expectations regarding the use of AOG in education.

The results of systematic reviews of literature sources on the problems of personalized learning and adaptive learning systems are also given in other scientific publications, in particular: the study of individual differences taken into account in adaptive learning systems [182]; use of competency-based recommendation systems [322]; personalized electronic learning models as a combination of theories, methods and learning tools [111]; characteristics, application and evaluation methods of intelligent educational systems [177]; taking into account personal traits in an adaptive learning environment and building models of those who study [4].

In our study, two research questions were posed. First, "are the issues of personalized and adaptive learning using ICT relevant?". Second, "what ICT tools are used to personalize learning?". To solve them, a search and review of scientific publications made in the period 2010-2019 was carried out.

In the process of research, we relied on the methodological principles of conducting a literature review, outlined in works [62; 167; 246], as well as materials of scientific publications [4; 5; 182; 235; 322].

We analyzed scientific publications presented in the reference databases Scopus (https://www.scopus.com) and Web of Science Core Collection (https://www.webofknowledge.com), as well as electronic libraries of the Institute of Electrical and Electronics Engineers (IEEE, https://ieeexplore.ieee.org) and Association for Computing Machinery (ACM, https://dl.acm.org/). These sources of information were chosen because they contain influential world scientific publications. In order to select the most relevant and thorough research, it was decided to introduce additional restrictions, namely: articles in periodicals and materials of scientific conferences, books and parts of books published during 2010-2019.

The Scopus and Web of Science Core Collection platforms provide functionality for searching publications. In particular, the ability to filter by field of knowledge / category was used. In Scopus, the field of knowledge "Social Sciences" (Social sciences) was chosen, in Web of Science the category "Education educational research" (Education, educational research), since our research mainly concerned the educational process. The search was carried out by the Title, Abstract and Keyword fields.

At the first stage, in order to determine the general level of interest of scientists in the problems of adaptive and personalized learning, we conducted a search in three directions, which can be conventionally defined as: "personalization of learning", "adaptation of learning", "information system for learning" (learning information systems). Three key phrases were chosen for each direction, namely: "personalized learning", "individual learning", "direct instruction" ("personalization of learning" direction); "personalized e-learning", "adaptive learning", "intelligent tutoring" ("adaptation of learning" direction); "personalized learning environment", "adaptive learning system", "intelligent tutoring system" (direction "information system for learning"). In the process of selecting keywords, we relied on works [4; 95; 182].

At the second stage, for the selection of publications that present the results of experimental research in the field of adaptive learning systems, we formed a search query that consisted of four parts joined by the AND logical operator:

1) keywords for selecting publications that consider adaptive and personalized learning: (adapt* OR personali*);

2) keywords for selecting publications related to education: (education* OR "tutoring" OR instruction* OR course*);

3) keywords for selecting publications related to educational information systems: ("learning environment" OR "learning system" OR "tutoring system");

4) keywords for the selection of publications in which the results of the experimental approbation of adaptive learning systems are given: (evaluat* OR empiric* OR experiment* OR survey* OR questionnaire).

In order to answer the first research question "are the issues of personalized and adaptive learning using ICT relevant?", a search was conducted in reference databases and electronic libraries.

Analysis of the data obtained in the process of selecting publications for the key phrases *"personalized learning", "individual learning", "direct instruction", "personalized e-learning", "adaptive learning", "intelligent tutoring", "personalized learning environment", "adaptive learning system", "intelligent tutoring system",* allows us to conclude that over the last decade, researchers have paid considerable attention to the theoretical and practical aspects of personalized and adaptive learning, in particular, the use of information and communication technologies to provide opportunities for adaptation to the educational process (Table 1.2).

Table 1.2. Generalization of search results

Key phrases	Information resources			
	IEEE Xplore ® Digital Library	ACM Digital Library	Scopus	Web of Science
personalized learning	411	550	720	448
individual learning	399	709	1056	596
direct instruction	26	171	505	312
personalized e-learning	70	29	65	28
adaptive learning	1351	972	782	385
intelligent tutoring	860	973	916	523
personalized learning environment	22	31	75	25
adaptive learning system	83	46	139	45
intelligent tutoring system	291	348	859	235

The information obtained from the reference databases Scopus and Web of Science allows us to reveal the dynamics of the publication activity of scientists on the problems of personalized and adaptive learning over the years (Table 1.3).

Table 1.3. Distribution of publications on the problems of personalized and adaptive learning by years

Key phrase	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Web of Science										
personalized learning	19	15	24	27	23	49	88	86	72	45
individual learning	52	43	46	50	40	82	76	82	71	54
direct instruction	15	21	19	20	17	46	35	42	53	44
personalized e-learning	2	2	2	2	4	3	3	2	5	3
adaptive learning	25	20	18	28	24	35	65	68	55	47
intelligent tutoring	45	24	29	42	41	45	99	79	54	65
personalized learning environment	2	1	1	2	1	2	5	4	4	3
adaptive learning system	0	3	2	4	1	7	8	2	10	8
intelligent tutoring system	22	8	thirteen	18	14	27	47	31	24	31
Scopus										
personalized learning	46	35	55	50	48	78	75	91	110	132
individual learning	97	99	100	97	96	124	95	108	112	128
direct instruction	40	31	49	46	38	60	44	50	65	82
personalized e-learning	7	5	6	8	6	5	6	3	8	11
adaptive learning	63	55	52	63	57	70	99	93	123	107
intelligent tutoring	92	68	81	89	90	89	122	98	94	93
personalized learning environment	8	5	6	8	5	9	10	7	7	10
adaptive learning system	4	5	9	16	15	11	21	17	22	19
intelligent tutoring system	80	63	76	86	83	84	114	90	92	91

It is possible to state the persistent interest of scientists in the mentioned problems.

Means of reference databases Web of Science and Scopus also provide an opportunity to analyze the distribution of authors by countries of the world. Based on the analysis of relevant data, it can be concluded that the mentioned problems are relevant for many countries. Most scientists represent the United States of America. The leaders also include researchers from China, Spain, and Germany. In the Table 1.4 shows the three countries with the highest percentage of authors of publications for each of the key phrases.

Table 1.4. Distribution of authors of publications on the problems of personalized and adaptive learning by country

Key phrases	Percentage of the total number of authors of publications		
	the first	the second	the third
Web of Science			
personalized learning	USA 24.8%	China 18.3%	Spain 7.8%
individual learning	USA 13.4%	Germany 9.9%	China 6.0%
direct instruction	USA 36.9%	Indonesia 6.7%	Germany 6.4%
personalized e-learning	Australia 14.3%	Greece 14.3%	China 10.7%
adaptive learning	USA 19.2%	Taiwan 7.5%	Spain 7.3%
intelligent tutoring	USA 36.1%	Taiwan 8.0%	Spain 6.5%
personalized learning environment	USA 20.0%	Spain 12.0%	Greece 8.0%
adaptive learning system	USA 17.8%	Taiwan 17.8%	China 13.3%
intelligent tutoring system	USA 34.0%	Spain 8.5%	Canada 8.1%
Scopus			
personalized learning	USA 24.2%	China 13.6%	Great Britain 8.1%
individual learning	USA 19.3%	Germany 11.1%	Great Britain 9.8%
direct instruction	USA 47.7%	Australia 6.3%	Canada 5.5%
personalized e-learning	Greece 10.8%	Spain 9.2%	Great Britain 9.2%
adaptive learning	USA 22.6%	China 9.3%	Taiwan 6.6%
intelligent tutoring	USA 39.7%	Germany 6.6%	China 5.8%
personalized learning environment	USA 18.7%	Germany 9.3%	Great Britain 6.7%
adaptive learning system	USA 19.4%	China 15.1%	Taiwan 7.9%
intelligent tutoring system	USA 39.7%	Germany 6.5%	China 5.9%

In the process of selection in electronic libraries and reference databases of publications by search query *(adapt* OR personali*) AND (education* OR "tutoring" OR instruction* OR course*) AND ("learning environment" OR "learning system" OR "tutoring system") AND (evaluat* OR empiric* OR experiment* OR survey* OR questionnaire)* the following results were obtained: IEEE Xplore® Digital Library – 402; ACM Digital Library – 3215; Scopus – 1280; Web of Science – 573.

The distribution of publications by year according to Scopus and Web of Science data is given in the Table 1.5 and shown in Fig. 1.3.

Table 1.5. Distribution of publications on the problems of applying adaptive learning systems by year

Source	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Scopus	88	91	109	124	120	142	140	140	153	173
Web of Science	5	3	6	4	3	12	12	6	8	12

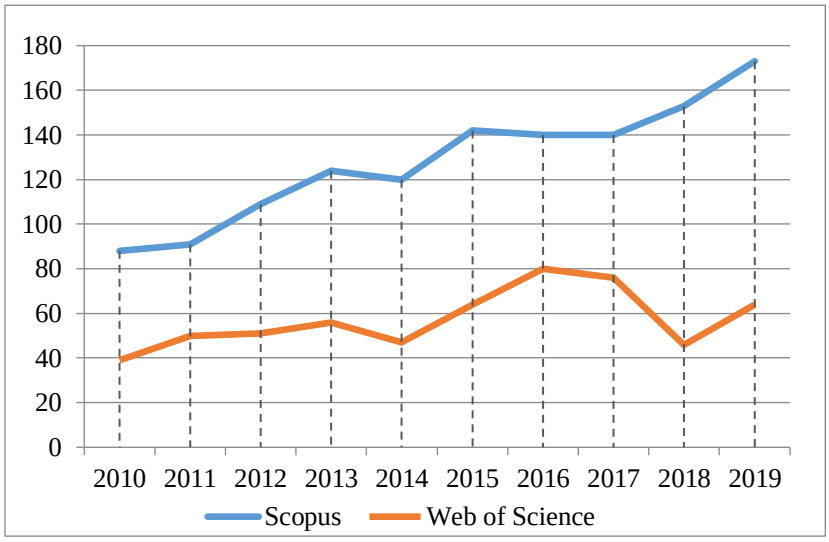

Fig. 1.3. Dynamics of publication activity on the problems of applying adaptive learning systems according to Web of Science and Scopus data

One of the indicators of scientists' interest in the presented materials, as well as the degree of influence of these publications in the field of research on the problems of adaptive learning in the educational process, is their citation rate. The distribution of publications selected by the search query by the number of citations is given in the Table 1.6. The table

is compiled on the basis of Scopus and Web of Science data, so the number of citations in materials indexed in Scopus and Web of Science, respectively, is taken into account.

Table 1.6. Distribution of publications on the problems of applying adaptive learning systems by the number of citations

Source	0 citations		1–49 citations		50–99 citations		100 or more citations	
	number	%	number	%	number	%	number	%
Scopus	352	27.5	876	68.4	38	3.0	14	1.1
Web of Science	271	47.3	284	49.6	14	2.4	4	0.7

Research results show that scientists are interested in personalized and adaptive learning using ICT tools. So, we can state their relevance for the theory and practice of education.

To answer the second research question, "What ICT tools are used to personalize learning?", we reviewed some scientific works devoted to the use of ICT tools to personalize learning, from the list selected at the previous stage of the research.

In [275], a rule-based scheme for providing adaptive assistance to students in the process of learning software, developed for an intelligent system of personalized learning, was characterized. Five strategies of adaptive support and sets of rules corresponding to the phases of planning, control, monitoring and reflection are defined. The researcher describes an intelligent learning environment built on these strategies and provides examples of the use of rule sets. Through experimental research, he points out the advantages of using the proposed approach. One of them is the manageability and extensibility of these strategies to support different educational disciplines [275, p. 553].

The work [239] discusses the problems of personalization of content and learning paths in mass open online courses. The authors of the article note that the platforms are focused on providing knowledge to many people, but this approach is not very effective, and many listeners do not achieve their educational goals. The researchers offer tools to integrate personalized learning objectives into the IVC platform and facilitate student engagement.

With the help of a special interface, they select learning goals that will further guide the educational process [239, p. 9].

The work [300] considers the methodology of creating a personalized electronic course with the possibility of adaptation to the learner. The authors offer the AdaptiveBook module for LMS Moodle, which collects data on student activity and helps build individual learning trajectories.

The recommendation module of the adaptive intelligent web-oriented learning system Protus is described in [128]. The authors note that tutoring systems can contain two categories of adaptability tools:

1) adaptive hypermedia for adapting the course to individual learning styles;

2) recommended methods to offer the most effective methods of learning [128, p. 886].

The recommendation system proposed by the researchers contains three modules:

1) the student-system interaction module, which collects data about their activities to build appropriate models;

2) an offline module that recognizes targets using constructed models;

3) a mechanism for compiling a list of recommendations [128, p. 888].

To study learning styles in four dimensions (information processing, information perception, information reception, information understanding), the authors use a data collection tool – the Learning Styles Index by R. M. Felder and B. A. Soloman [128, p. 889].

Based on the results of the analysis, the following main conclusions can be drawn:

- a person-oriented approach is sufficiently well developed in world pedagogical theory and practice, however, scientists continue to search for new ways of its implementation in order to achieve the maximum degree of correspondence of education to the demands and capabilities of the individual and to ensure conditions for education throughout life;

- personalized and adaptive learning provide such an organization of the educational process, in which a comprehensive study of the learner's personality is first carried out, then a model of his possible development is built, and subsequent influences and interactions are built taking into account this model, which, however, is not static and subject to adjustment;

- personality modeling of a student is based on data on the peculiarities of his educational activities, the collection and further processing of which is a complex, resource-intensive process that requires the involvement of specialists in various scientific fields, as well as the use of information and communication technologies;

- the development and implementation of adaptive learning systems, in particular based on the application of intelligent information technologies, aims to increase the efficiency of all the above-mentioned operations, and as a result, provide access to personalized education to all citizens;

- the organization of the educational process in a distance form actualizes research on the problems of applying adaptive learning systems, among which we consider it appropriate to highlight such directions as: improving the functionality of existing learning management systems, in particular the widespread Moodle platform, to provide them with means of personalizing learning (analysis of personal characteristics of students, formation of individual educational routes, adaptive delivery of educational content and assessment, etc.); professional training of specialists (psychologists, teachers, tutors) to use these systems in formal and informal education institutions.

Ultimately, it should be emphasized that personalized and adaptive learning with the use of information and communication technologies contributes to the development of the education system, in particular, the implementation of the principle of lifelong learning. There are several reasons for this statement. First, these approaches are based on models of learning styles and provide for meeting the educational needs of the individual under different circumstances. Secondly, the use of information and communication technologies helps to provide access to education to broad segments of the population.

1.3. Analytical review of adaptive learning systems

The use of adaptive capabilities of modern information and communication technologies in education has been considered in many scientific studies and presented at large-scale specialized scientific conferences. The use of intelligent systems in education is considered in publications [40; 66; 178; 96]. The principles of adaptive learning are considered in the study [105]. The works [38; 39; 59]. However, the problem of applying adaptive learning systems in domestic institutions of higher education has not been sufficiently reflected.

The application of the adaptive learning systems has the range of advantages, namely the opportunity of observance of individual convenient tempo of education and mastering of the specific material, that can significantly accelerate the process of acquirement of new information; the objectivity of the results of education and as-sessment of final result; the only system of assessment that gives the possibility to make the process of studies impartial; the complex of tasks can be created taking into account the separate way of perception of information by every student [303, p. 111].

Also to the advantages of the application of adaptive learning systems we can include the reduction of non-productive waste of live work of a teacher, who in this case is transformed to a technologist of the modern educational process, in which the leading role is attached not only to the educational activity of pedagogue but to the training of pupils themselves; providing pupils with the wide opportunities of free choice of their trajectory of learning in the process of school education; the foresight of differentiated approach to pupils, based on the individual previous experience and the level of knowledge (their own intellectual baggage, which determines the degree of understanding by pupil of new material and his interpretation); the raise of the efficiency of control and assessment of the results of studies; the increase of motivation of learning; the assistance of development of the productive, creative functions of thinking, the growth of intellectual abilities, the formation of operational style of thinking in pupils.

Let's consider the existing types of adaptive learning systems, based on the classification given in works [80, p. 14-18; 121, p. 130; 174]:

1) Macro-adaptive system – is the system that adapts the educational material for pupils at the macro level, grouping pupils according to the results of testing in groups. The participants have the common trajectory of education in the group, but such approach leads to the poor adaptation of education.

2) Micro-adaptive system – is the system that carries out the adaptation of education at the micro level, constantly reveling and analyzing the profile of pupils on the base of their activity and provides personified instructions. Such approach is more effective, as the individual trajectory of learning of every pupil is formed.

3) Aptitude-treatment interactions system (ATI) – is the system that is designed for big amount of people, but forms the individual instructive strategies, which are built on the base of specific propensities and characteristics of a pupil (for example, intellectual abilities and cognitive style, knowledge, style of learning, etc.). Such system allows a pupil partially or completely to adjust the process of his learning.

4) Intelligent tutoring system (ITS) – is the system that is realized by the means of artificial intelligence and is the hybrid combination of Micro-adaptive system and Aptitude-treatment interactions system. Such system for the formation of adaptive strategies of learning takes into account as propensity and also the needs of a pupil, applying the complicated structured model of a user.

5) Adaptive Hypermedia System (AHS) – is the hypermedia system that is built with the help of artificial intelligence and uses the model of a user, in which the pupil's personal information about knowledge, interests and goals for the adaptation of content and navigation in the hypermedia space is contained. The pupils, who have different goals and knowledge, can get interested in various information that is presented on the hypermedia pages and as the consequence can use the different links for navigation, or have the necessity in bigger annotation about the lecture etc.

6) Adaptive Educational Hypermedia System (AEHS) – is the specific Adaptive Hypermedia System, applied in the context of learning and consists of the document space, the model of a user, and the components of observation and adaptation. The tool that allows to create and hypermedia systems-tool for creating adaptive electronic textbooks (AET).

7) Adaptive Learning Platform (ALP) – is the platform that modifies the presentation of material in response to the results of pupils' activity, recording small data and using the educational analytics to ensure the individual adaptation.

8) Adaptive Deep Learning Platform (ADLP) – is the platform that is built on the set of methods of machine learning and the theory of artificial neural networks that is based on the learning by feature / representation learning and not on the specialized algorithms for the specific tasks.

9) Computer Adaptive Educational Assessment (CAEA) – is the platform that organizes the complicated adaptive testing, realizing the selection of test questions on the base of previous answers of a pupil and has the complicated model of assessment of the pupil's activity results.

10) Learning Objects Difference Engine (LODE) according to the definition of the developer is the program of the innovative learning, courses and experience of learning that uses the mechanism of differences for ensuring of learning on the base of competences, the personalized and AL. The technology of this educational environment is built on the creation of objects with programs and courses integrating publisher content, open educational resources, faculty content and other ed tech vendors' tools.

The results of the review of various types of adaptive learning systems are presented in the Table 1.7.

One of the largest and most functional adaptive systems available today is CogBooks. Courses posted on the platform are developed together with university researchers. According to Jim Thompson, CEO of CogBooks, thanks to adaptive systems, a new culture of education is emerging, and student success is increasing by 20% [10].

The company Knewton is known for the fact that it was one of the first to actively apply the technologies of analysis of data in the sphere of education. The adaptive educational platform that could be launched to any modern control system of learning process (LMS) was created as the result of this work. The methodology of Knewton is built around two main notions: the technologies of planning of educational trajectory and the complicated model of the student's assessment. Such approach differs dramatically from the majority of "adaptive applications", which indeed

apply the adaptive approach to single point in which the students' knowledge is measured. The example of such "fairly adaptive" approach is the diagnostic exam, according to the results of which a computer defines what content will be shown to a student further on. The technologies of data mining and the personalization are used minimally here or are not used at all. One of the developers of the adaptive tests for monitoring is NWEA that creates the adaptive tests for different goals. For example, the test MAP Growth is used for the periodic testing of pupils' knowledge of different subjects, while MAP Skills is recommended to be applied more often. Considering the adaptive learning systems let's research their territorial distribution. For this we will view the institutions of higher education at which the implementation and usage of the adaptive learning systems was carried out.

Table 1.7. Adaptive learning systems

Name	Website	Type	Developers	Year of development / last update	Cost	Realization		
						cloud orientation	*mobile version*	PC version
Course Arc	coursearc.com	ALP	B. Meyer, K. Egan	2015/2020	Trial/ Pay	+	+	+
Realizeit	realizeitlearning.com	ITS	DBA of CCKF	2007/2020	Pay	+	+	-
Brightspace LeaP	d2l.com/products/leap	ALP	Desire2Learn	1999/2018	Trial/ Pay	+	+	-
Möbius	maplesoft.com/products /Mobius/	ALP	Digital Ed	1998/2020	Pay	+	+	-
WileyPLUS	wileyplus.com	ALP	John Wiley & Sons, Inc.	2000/2020	Demo/ Pay	+	+	-
Revel	pearsonhighered.com/re vel/	ALP	Pearson	2012/2020	Pay	+	+	-
Junction	j unctioneducation.com	ALP	J unction education	2013/2019	Pay	+	+	-
Smartwork5	wwnorton.com/smartwo rk5	AET	W. W. Norton	2012/2020	Pay	+	-	-
MindTap	cengage.com/mindtap	LODE	Cengage Learning	2009/2020	Pay	+	+	+
InQuizitive	wwnorton.com/inquisiti ve	ALP	W. W. Norton	2000/2020	Free/ Pay	+	-	-
BNED	bnedcourseware.com	ITS	Barnes & Noble Education	2015/2019	Demo/ Pay	+	-	-

Name	Website	Type	Developers	Year of development / last update	Cost	Realization		
						cloud orientation	*mobile version*	PC version
Author	muzzylane.com	ITS	Muzzy Lane Software	2002/2020	Free/ Pay	+	+	-
Fishtree	fishtree.com	ALP	Fishtree	2012/2020	Free/ Pay	+	+	-
SmartSparrow	smartsparrow.com	ALP	University of New South Wales	2010/2018	Trial/ Pay	+	+	-
MindEdge	mindedge.com	AEHS	MindEdge, Inc.	1998/2020	Pay	+	+	-
Open Learning Initiative	oli.cmu.edu	ALP	William and Flora Hewlett Foundation; Carnegie Mellon	2001/2019	Free/ Pay	+	+	-
Learning Objects	learningobjects.com	ALP	Washington, DC	2003/2020	Pay	+	+	-
Straighterline HE	straighterline.com	ITS	Straighterline, Inc.	2008/2020	Pay	+	+	-
Knewton	knewton.com	ALP	Jose Ferreira	2008/2019	Trial/ Pay	+	+	-
WebAssign	webassign.com	AET	Cengage Learning	2003/2020	Pay	+	+	-
Omega Notes	omeganotes.com	ALP	Lang Enterprises LLC	2015/2020	Free/ Pay	+	+	+
ModCourse	modcourse.com	ALP	Little Bird Games	2014/2016	Free/ Pay	+	-	-
panOpen	panopen.com	AEHS	panOpen LLC	2013/2018	Pay	+	+	+
Drillster	drillster.com	ALP	Drillster BV	2006/2020	Demo/ Pay	+	+	+
CogBooks	cogbooks.com	ITS	*CogBooks*, Ltd	2015/2020	Demo /Pay	+	+	-
The Open Learning Initiative	oli.stanford.edu	ALP	Open Learning Initiative at Stanford University	2012/2020	Free/ Pay	+	-	-
iTutorSoft	itutorsoft.com	ADLP	Greater Washington DC (Vlad Goodkovsky)	2012/2019	Free	+	+	-
SoftChalk Create	softchalk.com	ITS	SoftChalk LLC	2002/2020	Pay	+	+	-
NWEA	nwea.org	ALP	Northwest Evaluation Association	1973/2019	Free/ Pay	+	+	-
GIFT	gifttutoring.org	ITS	US Army Research Laboratory	2009/2019	Free	+	+	+

Based on the analysis of the distribution of adaptive learning systems (Fig. 1.4), we conclude that they have become the most widespread in higher education institutions of the United States of America, but in other countries such systems are used little.

Fig. 1.4. Territorial distribution of adaptive learning systems

For a better understanding of the functionality of popular adaptive learning systems, the type of each of them was determined. The following abbreviations were used to indicate the type: Intelligent Tutoring System (ITS), Adaptive Educational Hypermedia System (AEHS), Adaptive Learning Platform (ALP), tool for creating adaptive electronic textbooks (AET), Adaptive Deep Learning Platform (ADLP), Computer Adaptive Educational Assessment (CAEA), Learning Objects Difference Engine (LODE). The use of natural language technologies (NLT), in particular the availability of natural language processing (NLP) and natural language understanding (NLU) technologies, was also subject to research. Among the factors by which adaptive learning systems were analyzed, single-point adaptation (Sp) and continuous adaptation (C) were also chosen. The analysis of the functional capabilities of adaptive learning systems is given in the Table 1.8, 1.9.

Table 1.8. Functional capabilities of adaptive learning systems

System	Competence oriented	Features				Integration with LMS						NLT	
		course designer	completed course	a pre-made course	additional means	Blackboard	Canvas	Brightspace by D2L	Moodle	Sakai	Schoology	NLG	NLP
CourseArc	-	+	+	-	+	+	+	+	+	+	+	-	-
Realizeit	+	+	+	-	+	+	+	+	+	+	+	-	-
Brightspace LeaP	+	+	+	-	-	+	+	+	+	-	-	+	+
Möbius	+	+	+	+	-	+	+	+	+	+	-	-	-
WileyPLUS	-	-	+	+	-	+	+	+	+	+	+	-	+
Revel	-	-	+	+	-	+	+	+	+	-	-	-	-
Junction	-	+	+	+	-	+	+	+	+	+	+	-	+
Smartwork5	-	-	-	+	+	+	+	+	+	+	+	-	-
MindTap	-	-	+	+	-	+	+	+	+	+	+	-	-
InQuizitive	-	-	+	+	-	+	+	+	+	+	+	-	-
BNED	-	+	+	+	-	+	+	+	+	+	-	-	-
SmartSparrow	-	+	+	-	+	+	+	+	+	-	-	-	-
Author	-	+	-	-	+	+	+	+	+	+	+	+	-
Open Learning Initiative	-	-	+	+	+	+	+	+	+	-	+	-	-
Fishtree	-	+	+	-	+	+	+	+	+	+	+	-	+
MindEdge	-	-	-	-	-	-	-	-	-	-	-	+	+
Learning Objects	+	+	+	+	+	+	+	+	+	-	-	+	-
Straighterline HE	+	-	+	+	-	+	+	+	+	+	+	-	-
Knewton	+	-	+	+	+	+	+	+	+	+	+	+	+
WebAssign	-	-	+	-	-	+	+	+	+	+	-	-	-
Omega Notes	-	+	-	-	-	-	-	-	-	-	-	-	-
ModCourse	-	+	+	-	-	+	+	-	+	-	-	-	-
panOpen	+	+	+	+	+	+	+	-	-	-	-	-	-
Drillster	+	+	-	+	+	-	-	-	+	-	-	+	+
CogBooks	-	+	+	+	-	+	+	+	+	+	+	-	+
Open Learning Initiative	+	-	+	+	-	+	+	+	+	+	+	-	-
SoftChalk Create	-	+	+	-	-	+	+	+	+	+	+	-	-
NWEA	+	+	+	-	+	-	+	-	-	-	-	+	+
iTutorSoft	+	+	-	-	-	-	-	-	+	-	-	-	-
GIFT	-	+	-	-	-	-	-	-	-	-	-	+	+

Table 1.9. Types of adaptive learning in different systems of adaptive learning

System	Types of adaptive learning			
	single point / continuous	adaptive learning	adaptive testing	comprehensive assessment model
CourseArc	C	+	+	+
Realizeit	C	+	+	+
Brightspace LeaP	C	+	-	-
Möbius	C	+	-	+
WileyPLUS	Sp	+	-	-
Revel	Sp	+	+	+
Junction	C	+	+	-
Smartwork5	C	+	+	-
MindTap	C	+	+	+
InQuizitive	C	+	+	+
BNED	C	+	+	+
SmartSparrow	C	+	+	-
Author	C	+	+	+
Open Learning Initiative	C	+	+	+
Fishtree	C	+	+	+
MindEdge	Sp	+	+	+
Learning Objects	C	+	+	-
Straighterline HE	C	+	+	-
Knewton	C	+	+	+
WebAssign	C	+	+	-
Omega Notes	C	+	-	-
ModCourse	C	+	+	+
panOpen	C	+	+	+
Drillster	C	+	+	-
CogBooks	C	+	+	-
The Open Learning Initiative	C	+	+	-
SoftChalk Create	C	+	+	+
NWEA	C	-	+	+
iTutorSoft	Sp	+	+	-
GIFT	C	+	+	+

Researching the opportunities of mentioned adaptive learning systems we will address to Ratings company self-assessment, guided by the CWiC Framework [236]. The characteristics according to which was researched the functional of adaptive systems of education was chosen Adaptivity (The content can be adjusted in relation to a learner's knowledge), Customization (Educators and course designers can alter learning or assessment content), Learner Autonomy (Learners can impact or augment instruction based on their choices), Socio-Emotional (Use of feedback and interventions based on a learner's social-emotional state), Assessment (The presence of academic structures and the capacity to assess learning in relation to them), Collaboration (Ability for learners and/or educators to engage with each other in the context of learning). For each parameter, a scale level was determined: Low (L), Medium (M), High (H). The results of the analysis are given in Table 1.10.

Table 1.10. Possibilities of adaptive learning systems

System	Opportunities					
	Adaptability	Customization	Learner Autonomy	Socio-Emotional	Assessment	Collaboration
CourseArc	L	H	L	L	L	L
Realizeit	H	H	M	M	H	H
Möbius	H	H	L	L	H	L
Junction	H	H	H	M	H	H
Smartwork5	M	H	L	L	H	L
InQuizitive	L	H	L	H	M	L
BNED	L	H	L	L	M	M
Smart Sparrow	H	H	H	H	H	M
Author	M	H	H	H	H	H
Open Learning Initiative	H	H	L	H	H	M
Straighterline HE	L	L	M	L	H	L
Knewton	H	H	L	L	H	M
WebAssign	L	H	H	L	M	M
CogBooks	M	H	L	L	H	H

The issue of improving the teaching methodology in educational institutions remains highly relevant for a long period of time, particularly the teachers attention is focused on e-learning itself and adaptive learning systems. With the transition to electronic learning, educators need to introduce new forms and methods of information, considering that information in its visual perception can be adsorbed in easier and prolonged way.

The instructional design plays an important role in providing a more efficient, productive and qualitative process of learning. The instructional design forms a coherent system of goals, learning material and available knowledge transfer tools. The instructional design is primarily aimed at filling the course with meaningful information, forming a sequence of presentation and introduction of modern ways of presenting educational material. However, the indicators of usability and ergonomics are equally important in the instructional design of educational materials for the electronic environment in correspondence with existing dependency between easiness of the education courses using and the quality of the material acquisition by the students. This is especially important in e-learning, where interaction between students, teachers and content is ensured not face-to-face, but through information and communication technologies [153].

The appropriate attention should be given not only to the content of the course, the methods and techniques to be used in the e-learning process, but also to the visualization of the educational content, to the indicators of ergonomics and usability of the platform on which the course is located. These elements should act in harmony in order to ensure high quality training.

Basic research on the issues of pedagogical design was reflected in the works of S. Denysenko [65], V. Tymenko [302], A. Uvarov [306] and others. scientists The authors of the works suggest using visualization of educational information as a tool for the development of cognitive learning activities [264; 76]. The issue of the basics of visual design was discussed in detail in works [53; 265]. The issue of usability in the pedagogical design of the MOOK was considered in the study [227].

Usability is a concept that can be applied to the analysis of the user interface of re-sources, which determines their convenience and ergonomics while using. Analyzing the usability of the user interfaces of the developed education courses in adaptive learning systems, we followed the recommendations given in J. Nielsen's classic book “Designing Web Usability: The Practice of Simplicity” [185]. Such features as design, especially taking into account its "flexibility" or "rigidity", page length; availability and interface of search tools; the nature and the means of the navigation procedure realization were analyzed. The proposed list of indicators and characteristics for the formation of criteria, by which the ergonomic quality of the interface was analyzed, has also been expanded with the indicators that are important due to the principles of the instructional design of educational materials. The particular attention was paid to the possibility of integration of various multime-dia fragments (video and audio accompaniment, integration of presentation material, integration of interactive elements, etc.) and to the functionality of testing elements (providing an individualized interpretation of false answers, cards, etc.). Equal emphasis was placed on the possibility of individualization and the design branding of educational materials, which would help to create a positive image of the educational institution, on the basis of which the system of adaptive learning is implemented.

The indicators’ characteristics of usability, ergonomics and the instructional design of education courses in the following adaptive learning systems: Knewton, RealizeIt, CourseArc, Brightspace LeaP, Revel, MyLab, Open Learning Initiative (OLI) and Generalized Intelligent Framework for Tutoring (GIFT) were analyzed and re-searched. Combined comparative analysis is given in Table 1.11.

So, the theoretical analysis of the indicators of the ergonomics of the training courses, developed by means of the available systems of adaptive training, confirms the improvement of the effectiveness of the pedagogical design of training materials. Summarizing what has been said, we recognize that the focus on increasing the level of ergonomic indicators and elements that follow the principles of pedagogical design of educational courses is an objective response of the system to the challenges of the needs of the modern student.

*Table 1.11. Comparative analysis of indicators of usability and ergonomics of pedagogical design of training courses of adaptive learning systems**

Characteristics	Adaptive learning system						
	Knewton	RealizeIt	CourseArc	Brightspace LeaP	Revel	OLI	GIFT
Design							
Moderate color scheme	●	○	●	●	●	●	●
Minimalistic design	●	◒	●	●	●	●	●
Adaptation for mobile devices	●	○	●	●	●	○	◒
Course branding	○	○	●	◒	○	●	◒
Navigation							
The user controls the navigation	●	○	●	●	●	◒	●
Search capabilities	●	◒	●	●	●	◒	●
User Posted Content	●	○	●	●	●	◒	●
Hierarchy of topics	●	●	◒	●	◒	◒	●
Skill system	○	●	○	○	◒	○	○
Success statistics							
Progress bar	●	◒	○	●	●	○	○
Details of success	●	○	◒	○	●	○	○
Educational content							
Management of books	●	◒	●	●	◒	◒	●
Curriculum management	●	○	●	●	○	◒	◒
Management of the library of educational materials	●	◒	●	◒	◒	◒	●
Image support	●	●	●	●	●	●	●
Support for video fragments	●	●	●	●	●	●	●
Support for audio fragments	●	○	●	◒	●	●	◒
Presentation support	●	○	●	○	○	○	●
Interactive elements	◒	○	●	○	●	○	○
Testing functionality	●	◒	●	●	●	◒	◒
Storyboard	○	○	○	○	◒	○	○
Gamification of learning	○	○	◒	◒	◒	○	○

* conventional designations: ● – the best indicator, ◒ – fragmentary available, ○ – absent.

According to the research results, it can be concluded that adaptive learning systems have a wide functionality for building individual educational trajectories, implementing personalized and adaptive learning. Currently, adaptive learning systems are just beginning active development and gradual implementation. Even in the developed countries of the world, such systems have not yet gained significant popularity and are undergoing experimental testing. Compared to the developments of previous generations, they are better and faster adjusted in the work process, characterized by flexibility and openness to modifications, which ultimately allows for individualization, personalization, and a personally oriented approach to learning. The algorithms of adaptive learning systems evaluate the results of each student in real time and, depending on this, adjust the content, pace, etc. The functioning of such systems is based on a competency-based approach, orientation on individual progress. In view of the above, we consider it relevant and promising to study the theoretical foundations of designing and implementing adaptive learning systems in the educational process, as well as making methodological recommendations for use in the educational process.

1.4. Analysis of the experience of blended learning in foreign institutions of higher education

The development of society stimulates changes in educational processes. The emergence of new trends in industry, production and science encourage the search for new ways of improving higher education, which is designed to provide society with highly qualified personnel. One of the ways to improve the quality of higher education is to study the experience of leading teaching practices with the aim of introducing the best into the educational process of higher education institutions of Ukraine.

Currently, one of the main trends in higher education in Ukraine is a student-centered approach, which can be provided with blended learning technologies that make learning convenient and flexible. The blended learning format is a way for students to become active participants in their studies, thereby developing new professional skills. Taking into account the fact that blended learning technologies first became widespread in foreign education, it is appropriate to study the experience of the leading countries of the world regarding the use of blended learning in higher education.

Foreign scientists widely considered the theoretical and practical aspects of blended learning in higher education: the practical application of blended learning was presented by D. R. Harrison and N. D. Vaughan; three different approaches to the design of blended learning – A. Alammari, J. Sheard, A. Carbon; institutional and strategic issues of the implementation of blended learning at the university – V. V. Porter, Ch. R. Graham, K. I. Spring, K. R. Welch; recommendations for teachers on the implementation of blended educational design in their courses – D. R. Harrison, N. D. Vagan, etc.

In particular, S. R. Graham [93] defined blended learning as a combination of personal learning and computer instruction, where two traditionally separate educational systems are combined, and the role of computer technologies is emphasized. The purpose of blended learning should be to combine the best features of classroom learning with the best online learning opportunities, promoting active, independent learning opportunities for students. A. A. Okaz [188] argues for the integration

of blended learning in institutions of higher education by the presence of students of nomophobia (a feeling of fear and anxiety in a person due to the absence of his mobile device), and therefore considers it expedient to use mobile phones in the educational process.

Theoretical and methodological aspects of blended education in institutions of higher education are considered in the scientific works of V. Kuharenko, S. Berezenska, K. Bugaichuk, K. Osadcha, V. Osadchyi, V. Kruglik, I. Naumuk, and others. Scholars [149] point out that blended learning is becoming widespread in the field of higher education, and blended learning approaches have emerged as one of the most popular technologies today because they allow you to take advantage of the flexibility and convenience of distance technologies and the advantages of the traditional classroom. Middle and advanced blended learning is a self-blending model where students take individual online courses by themselves and attend traditional classrooms. For the effective implementation of blended learning in higher education (master's degree), it is important, according to researchers [194], to clearly define and understand blending options and models of blended learning by teachers; development of a strategy for the implementation and implementation of blended learning; appropriate selection of information and communication technologies to ensure blended learning; development of educational materials for blended learning and their constant revision and updating, taking into account feedback from students and new achievements of science and technology; clear definition and communication to students of the requirements for training, accounting of results and conditions for preparing the final control; well-configured communication between teachers and students with the help of ICT; systematic and transparent monitoring of the learning process and notification of students about the results of the evaluation of their educational activities.

Attempts to analyze the foreign experience of implementing blended learning were made by G. V. Tkachuk (USA, Finland, Germany, Great Britain, Sweden, Belgium, Switzerland, China), A. A. Zasluzhena (Switzerland), I. Zadorozhna (USA), G. Davydenko (EU countries), V. Belan (Poland) and others. However, insufficient attention has been paid

to the study of the best practices of blended learning in foreign institutions of higher education.

Since the advent of computers and network technologies (in the 60s), scientists and teachers have tried to find ways to use them in the learning process. The concept of "electronic learning" appeared, which involved the use of computers and the Internet as the main means of implementing the educational process. Eventually, the use of technology is combined with traditional learning and the concept of blended learning emerges, which combines the use of the Internet with a large number of other diverse approaches and technologies (both educational and informational) to create an integrated learning experience.

In the process of the evolution of blended learning, scientists and teachers developed blended learning practices in institutions of higher education. Let's consider the work of foreign scientists on the implementation of blended learning.

Based on the experience of organizing corporate blended learning, J. Bersin [26] offers the following modes of training (Fig. 1.5):

1) Reading. When the material is in a well-designed book form, reading is very effective for visuals. In the web form, reading is less valuable because people mostly can't read long manuscripts online. Hence, reading on the web is more of a source of reference material than learning.

2) Vision. Diagrams, photographs and images are added to the text during the learning process and these visual images add extraordinary new conceptual understanding. In a web form, visuals can be animated to show moving processes. They can include interactivity (reactions to what they see), which allows learners to actively participate in the educational process.

3) Hearing and 4) Observation. These methods include teacher lectures, demonstrations, videos with real-life examples, and scenarios. It adds an auditory learning experience to the already existing mix (text and images), improving interest and retention.

5) Action (Learning by experience). The highest level of mastery comes from experiential learning: learning by doing. It is a learning activity that creates a high level of understanding, context, and retention. Blended learning should strive to create experiential activities that allow for computer

simulation, a special form of web-based training that immerses the learner in a real situation.

6) Learning while teaching. Undoubtedly, the most valuable way to master a subject is to teach it.

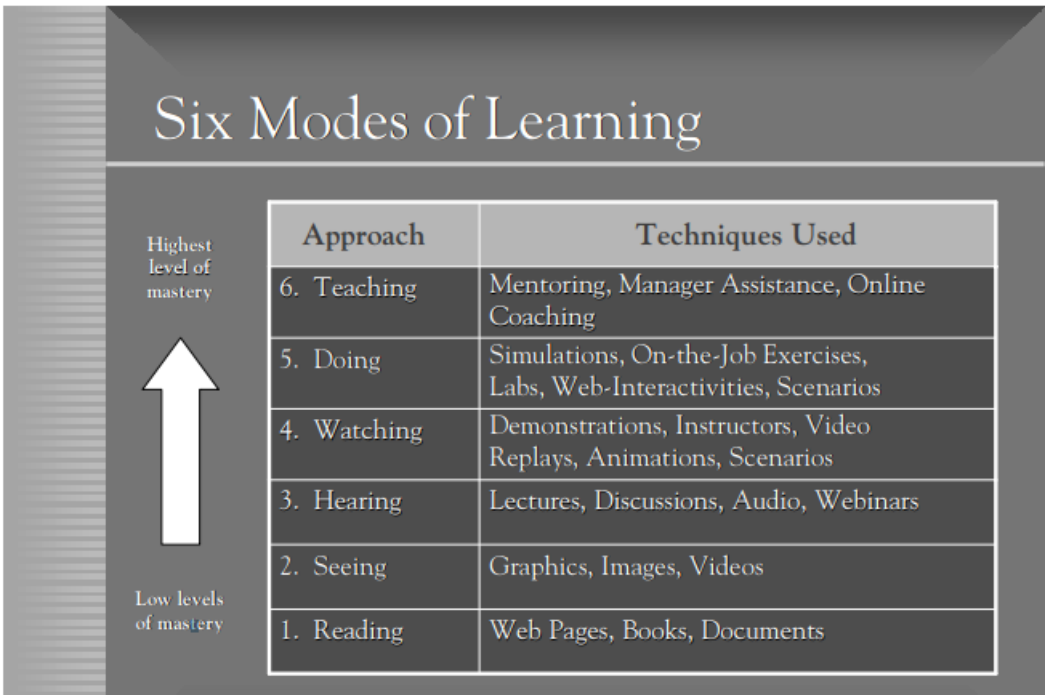

Fig. 1.5. Six modes of blended learning [26]

The step-by-step application of these modes in blended learning, according to the author, allows improving the learning process. And this is correct in combination with the proposed methods. After all, it is the student's progress from simple reading to teaching that will contribute to better assimilation of bulk material and deepening into the process itself.

For the effective implementation of the educational process, L. S. Fitch [81] singles out the following basic elements for the implementation of a blended educational course:

- redesign – since the transition to a blended environment affects all levels of the course, it is necessary to redesign the entire course according to the following stages: determine the learning outcomes and how students will demonstrate mastery; define additional steps to achieve the result and goals for each step; determine course activities and tasks that contribute to the achievement of course goals by students; determine the appropriate

way to use Internet technologies for each type of activity or task and connect Internet activities with face-to-face learning;

- goals and expectations – it is important to clearly articulate goals and expectations for the course, as well as for each lesson or learning unit;
- classroom and online environment – a sequence must be created so that online activities are transferred to the classroom or classroom activities are transferred to the online environment;
- organization – it is important to keep things simple and clear in the organization of blended learning, especially in an online environment, for which it is advisable to have all learning materials in one place or at least to have an obvious organizational structure.
- clarity – in the classroom, students can get immediate answers to questions or advice on a problem, but in an online environment they depend on asynchronous communication, so it is especially important to be clear to avoid conflicting instructions and inaccurate information;
- time management – students need to learn new online skills, they need to take more responsibility for their learning and time management, and the teacher needs to help them by providing guidance on how they should participate in course activities. In addition, it is advisable to use surveys to find out how much time students spend on tasks and whether adjustments need to be made to the timing of the course.

In the course of the spread of blended learning technology, various approaches to their use in the educational process were tested and researched. Early studies questioned the relationship between blended learning and increased student self-efficacy [159], and also showed that online education offered without a blended environment negatively affects interpersonal relationships, as online classes lack the usual physical proximity [280]. There was also the question of whether teachers can fairly assess academic achievement and provide adequate feedback to students in a relatively new blended environment [63].

The authors of the report "Student Experiences of Blended E-Learning: A Review of UK Literature and Practice" [256] highlighted the following educational implementations of blended learning: Blending to promote associative, constructivist and situated learning. Associative models of learning assume that people learn by association, first through basic

stimulus response, later through the ability to connect concepts in a chain of reasoning or connect steps in a chain of actions to form a complex skill. This results in accuracy of reproduction or recall. In constructivist models, learning occurs through active construction of ideas and formation of skills, through research, experimentation, feedback and appropriate adaptation. Students engage in activities that focus on real-world, authentic tasks and require collaboration with peers.

Interesting research on the practice of implementing blended learning was carried out by Finnish scientists. In a collective monograph [114], they provided examples of ideas on how to design blended courses and test new ways of combining traditional face-to-face learning with online learning environments. Let's dwell on the most interesting of them.

N. Vaughan [114, p. 13-15] describes blended learning environments in higher education and how the basics of the concept of "Community of Inquiry" (CoI) can be used to develop blended learning courses and programs. CoI has three main elements – social presence, cognitive presence and teaching presence. Each of these elements and their combination must be considered in the design and delivery of blended learning activities and outcomes. Social presence is defined as the ability of participants to identify with community interests (e.g., a course of study), to communicate purposefully in a trusting environment, and to develop interpersonal relationships through the participants' projection of their individual identities. Due to cognitive presence, the depth and significance of the learning experience is realized. The teaching presence provides leadership that guides and sustains a productive community, responsible for designing, facilitating, and directing the educational experience of students.

For the effective organization of blended learning, E. Lindfors [114, p. 36-39] emphasizes the importance of collaboration and a successful learning community, noting that collaboration refers to a learning situation where a group of students work together, working toward a common goal and trying to understand and explain certain phenomena together. In this case, the use of ICT and especially the collaboration of the learning community can contribute to innovative solutions to promote high-level learning through deep understanding and knowledge construction. However, interest in joining a virtual learning community and previous experience

of participation are absolutely essential elements in learning communities. After all, there is no general schedule of actions, and the idea is that everyone can join the learning community when it is convenient. This means that the participant must make a schedule and stick to it in order to be able to complete the necessary tasks. And this, in turn, is possible with the help of good instructions or pedagogical scenarios, thanks to which participants can plan their intensity of work and adjust it according to the given tasks. Therefore, according to E. Lindfors, without support and guidance, there will be no common community of students, therefore the role of the teacher (tutor) consists precisely in promoting cooperation, in particular by continuing the discussion with his comments without directly interfering in the course of the discussion, supporting students in promoting joint work, directing participants to act as members of the learning community, etc.

T. Auvinen, L. Hakulinen and A. Korhonen [114, p. 127-135] offer a solution to the problem of teaching a large course using blended learning. Using the example of developing and conducting the "Data Structures and Algorithms" course, they offer a combination of contact (face-to-face) teaching with automatic assessment of exercises in the TRAKLA2 interactive learning environment and the use of other computer learning tools (PeerWise, Rubyric). As a result, interesting conclusions were made that: online educational environments provide platforms for active learning; automatic check of exercises allows you to cover a large number of topics; face-to-face and online learning can be both active and passive, depending on how it is carried out; automatic assessment allows feedback on a very large number of mechanical exercises, while face-to-face training is suitable for a smaller number of exercises that require more abstract thinking; the implementation of collaborative learning and students working on the creation of learning materials is an interesting concept that can help reduce the workload of staff in large courses. Also, scientists claim that since one monolithic system cannot be expected to meet all the requirements of different courses, there is a need for technology that allows combining separate systems into one. A step towards such a distributed learning environment is single sign-on technology, which allows students to log into different web environments using only one password, even if the systems are located at different universities.

The study of A. Leino is devoted to the application of the virtual environment in the process of teaching the discipline "User Interfaces". In it, he reveals an interesting experience of designing, planning and developing a blended course using the Second Life environment. The author notes that "the virtual world made it possible to do what would be impossible in more traditional conditions, but on the other hand there was so much new that problems were also inevitable" [114, p. 158]. Among such problems, problems with technical equipment related to the limited capabilities of the network and computer equipment at the university were noted; the need for additional support from a technical specialist for conducting simultaneous lectures in the virtual and real world; ethical problems related to mischief of students allowed in the virtual world; the negative attitude of some students to getting another account and getting to know a new learning environment. In the end, the author rightly summarizes: "taking your class into the virtual world is a huge leap, and therefore it should be taken only if the course can actually use the strengths of this environment" [114, p. 164].

H. Forsman [114, p. 190-192] proposed blended learning during students' work on innovative projects of small enterprises as a tool for entrepreneurial learning. From the students' point of view, the educational concept was aimed at creating an entrepreneurial learning environment that stimulated creative thinking, generating innovations, and opened up new business opportunities to students. From the point of view of small businesses – to intensify their innovation efforts by creating and developing new inventions and concepts to improve their business. From the university's point of view, the goal was to integrate the university's tasks in research and development work with education in the field of entrepreneurship. The training concept was organized in Finnish universities of applied sciences as part of an innovation competition. During her observation and research on the implementation of blended learning in the work process of student teams as developers of innovations for small enterprises, H. Forsman identified two types of learning: adaptive and generative.

Learning characterized by a sequential and planned process, the use of analytical knowledge and a focus on existing customers or expressed customer needs leads to adaptive learning and gradually to inventions.

The process of training such student teams can be described by the phrase "Do it better". These teams used the asynchronous virtual environment mainly to find information, instructions, facts and figures, they used personal e-mail to communicate and did not share their knowledge or problems through the virtual environment with other participants. In the Virtual Innovation Final, these teams had difficulty effectively and calmly using the synchronous virtual environment to present their ideas to the jury.

On the other hand, a learning process characterized by discovery, exploration, and experimentation with a focus on unexpressed customer needs and potential future markets leads to generative learning and inventions that are more radical in nature. The process of training such student teams is described by the phrase "Break the boundaries". The teams used the asynchronous virtual environment not only to search for information and instructions, but also to search for new ideas, potential partners, and the knowledge of other participants. In the Virtual Innovation Finals, these teams demonstrated a much better ability to use a synchronous virtual environment to present their ideas to an audience and convince the jury members.

Analyzing this study, it can be concluded that virtual environments can be used not only for organizing the learning process in its classical sense, but also for conducting research and development work of students, in particular during dual education.

Important conclusions for the practice of blended learning were made in the study of the American scientist G. Gomez [90], namely: blended learning requires a more active approach to the educational process from both students and teachers; it is important to understand that the role of teachers is changing from "sage on the stage" to "management from the side"; blended courses require skilled teaching to be successful; the relationship between teachers and students should be one of partnership to provide students with ways to absorb learning materials and enable more effective learning or the development of learning strategies that will lead to success.

A relatively small part of modern research on the problems of blended learning is devoted to issues of institutional implementation. V. V. Porter [225] examines this issue in his research, aiming to help higher

education institutions strategically organize and implement blended learning at the university. The authors conducted a preliminary study in which they proposed a framework for institutional implementation, distinguishing three stages: 1) awareness / research, 2) adoption / early implementation, and 3) mature implementation / growth. The researchers presented recommendations for the introduction of blended learning at the university in the form of a table (Table 1.12).

The research of German scientists H. Popp and N. Hofmann [224] was aimed at finding out the effectiveness of using interactive video in blended learning. In their proposed blended learning style, the virtual part is represented by short theory videos, interactive tests and a video explaining the test task and implemented as a preparation for the face-to-face class. The face-to-face phase is designed exclusively interactively: students repeat the virtual content, answer questions, solve tasks in groups of two, present and discuss the results. This study found that using the flipped classroom method allowed students to improve their final exam scores by an average of 0.4 compared to pure classroom teaching or pure virtual teaching.

The experience gained by many scientists of conducting blended learning allowed foreign educational institutions to quickly implement it during the coronavirus pandemic. In particular, S. Katzel and K. Durst [123] proposed the concept of blended learning, which uses the advantages of face-to-face and online teaching, which allows maintaining a high level of learning flexibility and promotes the development of digital skills of the future, such as digital literacy, digital learning, digital interaction and collaboration. During training, they offer a wide range of ways to activate students' learning activities: game rounds of entry and exit (preferably with the webcam enabled), questions about the studied material, previous experience or own opinion using voting or chat tools, gamification elements such as quizzes, joint brainstorming or brainwriting or polling methods using a digital board, etc. Therefore, this study has once again confirmed the effective experience of implementing blended learning, when it is very important for successful learning that self-learning tools supported by ICT and elements of classical presence are closely interconnected in a significant way.

Table 1.12. Recommendations for the introduction of blended learning at the university

Topic		Result
Strategy	Appointment	Institutions must align their goals for adopting blended learning with both institutional and teaching goals and values.
	Protection	Institutions must identify and support advocates at multiple institutional levels, including school and department administrations, faculty and student resource centers.
	Definition	Institutions must promulgate a unified definition of blended learning that identifies its structural dimensions, such as the integration of face-to-face and online instruction. Instructors must maintain the flexibility to make pedagogical decisions about redesigning a course for blended learning.
Structure	Infrastructure	Institutions should prepare to scale their initial efforts to adopt blended learning by upgrading their servers, bandwidth, and other infrastructure.
	Planning	Organizations should clearly state their blended learning offerings in their course catalogs in a way that accurately reflects any consequent reduction in learning time.
	Management	Management of blended learning should involve administrators of institutions and departments, as well as teachers.
	Assessment	Institutions must set grades based on commonly accepted course evaluations, grades, and outcomes in traditional and blended classrooms
	Professional development	Institutions must consider a number of variables when choosing professional development methods, including potential training providers, the number of employees who need training, and the needs of all participants in the educational process.
Support	Support service	Institutions should identify and meet the needs of faculty and students participating in blended learning.
	Stimulation	Organizations should consider providing incentives for those who implement blended learning, such as financial compensation, additional time to implement or adopt blended learning during tenure and promotion.

The analysis and generalization of the experience of blended learning in foreign educational institutions was made in order to study the best practices of blended learning in higher education. It is important in the analyzed studies that the authors made conclusions about the impact of the implementation of blended learning on student learning outcomes. Summarizing their results, the following effective practices of blended learning in higher education can be identified:

1) step-by-step application of blended learning modes (reading, seeing, listening, observing, acting, teaching);

2) application of the main elements for a blended learning course – redesign of the learning course, definition of goals and expectations, appropriate combination of activities in the classroom and in the online environment, clear organization of communication, optimal management of time for learning;

3) promotion of associative, constructivist and situational learning in the course of blended learning;

4) application of the concept of "joint research";

5) taking into account the importance of cooperation and a successful learning community in blended learning;

6) the use of educational environments for active learning and a single platform that allows combining separate systems;

7) introduction of virtual world technology in blended learning;

8) integration of educational, research and development work in one environment;

9) use of interactive video in blended learning;

10) organization and implementation of an effective structure for the institutional implementation of blended learning in higher education institutions.

It should be noted that the integration of research and practical examples of the experience of blended learning abroad provides a basis for their introduction into the practice of higher education institutions of Ukraine.

Predicting the future of blended learning technologies in higher education is difficult, as their application continues to evolve at a rapid pace. As opportunities for interaction and collaboration in blended learning environments increase through the proliferation of information and

communication technologies, higher education institutions must implement collaborative constructivist approaches that engage students in learning and research communities. After all, joint learning goes beyond the passive exchange of information, which is ineffective at the current stage of the development of education and society. For this reason, blended approaches will have a transformative impact in both traditional and blended learning.

CHAPTER 2.
MODELING OF AN ADAPTIVE SYSTEM FOR INDIVIDUALIZATION AND PERSONALIZATION OF THE PROFESSIONAL TRAINING OF FUTURE SPECIALISTS UNDER CONDITIONS OF BLENDED LEARNING

2.1. The concept of an adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended learning

Adaptive learning technologies are among the most promising in the field of higher education [287]. They are one of the means of improving the professional training of future specialists. Under the conditions of the coronavirus pandemic, such technologies become especially important [195]. The development of adaptive learning systems is devoted to the work of foreign researchers (M. Siadaty, F. Taghiyareh, S. Chen, J. Zhang et al.) and Ukrainian (O. I. Gorokhovskyi, O. I. Ryzhov, T. I. Troyanovska et al.) scientists, but there are not enough works devoted to modeling and development of a system that combines the possibilities of adaptive technologies, individualization and personalization under the conditions of blended learning of a higher education institution for improving the professional training of future specialists.

The theory of adaptive learning is devoted to the work of R. Glaser [85], F. M. Lord and N. Hillsdale [158], V. I. Bondary and others [1], individualization and personalization of training – I. V. Shestopalova [259], S. Graf and Kinshuk [92], blended learning technologies – J. Bersin [26], D. R. Garrison and N. D. Vaughan [84]. The practical experience of designing and developing adaptive learning environments is presented by O. A. Ryzhov [244], Ch. Chen et al J. Zhang [54] and others.

Adaptability is considered by scientists as the quality of the education system adapted to the levels and characteristics of those who study, in which the adaptation of the system to the student and the student to the system is ensured [82, p. 11]. Adaptive learning as a set of methods and approaches that allow expanding learning opportunities through self-control and

effective cognitive strategies of students; implies an alternative and flexible concept of using forms, methods, means, technologies and approaches in education, which encourages students to flexibly respond to tasks, modify them and / or their behavior during learning [240]. For the development of adaptive learning systems, the first stage is the definition of conceptual foundations that will determine the main purpose of the developed system.

The concept of an adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended education (hereinafter the Concept) represents a system of views on the theoretical and methodological basis and instrumental means of substantiating and developing an adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended education in higher education institutions of education of Ukraine.

The legal basis of the Concept is the provisions of the current legislation of Ukraine and other normative legal acts regulating the issues of higher and additional professional education and distance learning, namely: Standards and recommendations on quality assurance in the European area of higher education (2006) [269], Resolution of the General UN Assembly "Transforming our world: Agenda in the field of sustainable development for the period until 2030" (2015) [296], Concept of development of educational institutions in Ukraine (2000) [170], Regulations on distance learning (2013) [169], Decree of the President of Ukraine "On the National Strategy for the Development of Education in Ukraine for the Period Until 2021" (2013) [191], Concept of the Development of Education of Ukraine for the Period 2015-2025 (2014) [58], Law of Ukraine "On the National Informatization Program" (2015) [154], Law of Ukraine "On Education" (2017) [190], Law of Ukraine "On Higher Education" (2017) [155], Concept of development of digital economy and society of Ukraine for 2018-2020 (2018) [49], Recommendations on the implementation of blended education in institutions of vocational pre-higher and higher education (2020) [237].

The concept is based on the fundamental theory of modern general pedagogy (theory of the integral pedagogical process, pedagogical creativity, pedagogical systems, orientation of the individual in the world of values,

management of the educational process, etc.), professional pedagogy (theory of professional and personal self-determination, professional and creative training of future specialists, professional culture, professional self-education, personality formation, training activation); of higher school pedagogy (theory of innovative activity, pedagogical quality metrics, pedagogical modeling, pedagogical technology). It is based on the ideas of the humanistic paradigm, namely: the subject of professional training is a free individual who needs self-development and self-improvement; the content, forms and methods of education should be oriented to the personality of the student, the harmonious development of his personal and professional qualities; organizational and pedagogical conditions in higher education institutions should contribute to the harmonious formation and development of various abilities of the student, in accordance with his individual educational request.

The concept defines the leading idea, goal, tasks, methodological approaches, organizational and pedagogical conditions of functioning of the adaptive system for individualization and personalization of professional training of future specialists under the conditions of blended education.

The leading idea of the concept is based on the fact that the adaptive system for the individualization and personalization of the professional training of future specialists under the conditions of blended learning (ASIPPT) should be built on the basis of the complex and systematically determined use in the higher education institution of modern information and communication technologies and forms, methods, means and learning technologies to ensure adaptive learning, an individual and personalized approach in the process of professional training of future specialists.

The concept is based on the fact that ASIPPT functions in a higher education institution, in connection with which it is characterized by such systemic features as openness, coordination of different levels (HEI – faculty – department), subject-subject relations (teacher – student), the integrity and interrelation of structural elements, orientation towards achieving the result of improving the professional training of future specialists under the conditions of blended learning of higher education institutions.

In order for graduates of higher education institutions to be competitive on the labor market, it is necessary to apply modern pedagogical and information technologies in the process of professional training of future specialists. At the junction of these technologies, there is now the technology of adaptive learning. The basis of adaptive learning is a different from the traditional model of the organization of the educational process. Instead of discrete management of student learning, when tasks are issued in portions at each session, in adaptive learning, learning is continuously managed with the help of an operational self-report schedule and a network plan [186] developed by the teacher, or with the help of an electronic adaptive learning system, which does this based on appropriate algorithms. The peculiarities of adaptive learning are that it allows improving the independent work of students, contributing to the development of their independence, self-control, self-analysis, responsibility for the chosen individual educational route.

The purpose of ASIPPT is to use a flexible informational and educational environment that provides teachers and students with different individual characteristics and personal preferences with the means to improve professional training. An important aspect of ASIPPT is the orientation of students to self-awareness, analysis and understanding, and not just to listening and replicating educational material in the process of their professional training at higher education institutions. Under the conditions of work at ASIPPT, each student can study independently at the pace that corresponds to his psychological characteristics when solving educational tasks, turning to the teacher in case of need for advice or help. Therefore, ASIPPT ensures optimal adaptation of the educational process in higher education institutions to the individual characteristics and personal preferences of the student, promotes the activation of students' cognitive activity, increases motivation to study, and also provides the opportunity to monitor education and accordingly adjust the content of education to achieve planned individual results. ASIPPT has the potential to ensure the full involvement of all students in the process of building their individual educational program, developing their activity, improving the individualization of the educational process within the framework of one class, one educational program, and the entire higher education institution.

The purpose of ASIPPT is specified in the following tasks:

1) Implement adaptive learning technologies in higher education institutions: adaptation of educational materials, adaptation of control (testing), adaptation of devices, adaptation of face-to-face classes.

2) To introduce an individual approach to the process of professional training in the system of distance and face-to-face learning thanks to the study of individual qualities of students, support and accompaniment of the individual educational program of the student, individualization of the learning process, development of individual characteristics of the student and the formation of new characteristics according to his educational request, monitoring of individual progress.

3) To organize a personal educational environment for professional training of future specialists, including an electronic one.

4) To implement the systematic use of modern information and communication technologies and modern technical means of education to ensure the professional training of future specialists under the conditions of blended education of higher education institutions.

5) Monitor the formation of professional competence of future specialists in the adaptive system of higher education.

The general scientific basis of the adaptive system for the individualization and personalization of the professional training of future specialists under the conditions of blended education is the *systemic approach* (P. K. Anokhin, A. I. Uyomov, E. G. Yudin, V. V. Sedimentary). It allows you to present the process of professional training in the form of an adaptive system, define and characterize its components, identify relationships and interdependencies, and substantiate the system of key research concepts.

The adaptive approach is one of the fundamental approaches, because the main property of the developed system is adaptability. The main functions of the adaptive approach are as follows:

1) *motivational*, based on the reconstruction of stereotypes of personality activity, understanding the active role of the teacher in choosing strategies and methods of work, in achieving the desired result of educational activity;

2) *organizational and target*, which is expressed in the approximation of the goals of those who participate in the educational process, taking into account the individual characteristics of students;

3) *content-projective*, which involves the selection of educational information, the variability of educational plans and programs, the construction of new educational models;

4) *technological-management*, which involves modeling, the use of multi-level and differentiated training, which includes an alternative choice of forms and methods of conducting classes and a change in socio-educational orientations [143].

Synergistic approach (I. V. Anisimov, V. G. Kremen, S. S. Palchevskyi, V. I. Suhakov, G. Hacken) reflects the design of adaptive mechanisms in the system for its adaptation to internal or external changes that may lead it to an unbalanced state.

Cybernetic approach (V. P. Bespalko, L. B. Itelson, N. I. Kravchenko, M. V. Mironova, R. V. Mayer, N. F. Talizyn) in ASIPPT determines the functioning and optimal management of education in it, including mathematical modeling of the educational process and its main subjects and means – modern information technologies.

Environmental approach (K. G. Krechetnikov, Yu. S. Manuylov, Z. I. Udych, V. I. Yasvin, O. V. Yaroshynska) ensures the organization of the educational process under the conditions of the information and educational environment of the higher education institution, which provides an opportunity for the formation of a personal electronic educational environment of the student.

Individual approach (E. V. Kalugina, O. P. Mytych, A. I. Plygina, I. IS. University of Applied Sciences) provides for taking into account the individual characteristics of students in all its forms and methods, regardless of what characteristics and to what extent they are taken into account in the process of professional training.

Using *the competence* approach (M. Yu. Kademiya, O. V. Ovcharuk, Yu. M. Rashkevich, V. I. Ryabchenko, L. S. Tarkhan) is aimed at the fact that the focus of his attention is "the interrelationship of expectations of future or realized professional activity with the functional characteristics of the subjects of this activity" [328, p. 44]. It was used to identify the structure and content

of competencies that are formed in the process of professional training of future specialists.

Active approach (B. G. Ananiev, L. S. Vygotsky, P. I. Halperin, A. N. Leontiev, S. L. Rubinstein) at ASIPPT is aimed at implementing the principles of practice-oriented education, the use of active learning methods based on the principle of "learning through action".

Thanks to *the contextual* approach (A. V. Verbytskyi, E. B. Johnson, I. O. Zhukova, N. P. Khomyakova, K. V. Shaposhnikov) organization of training in the information and educational environment of higher education institutions is carried out, which allows access to a wide range of educational materials organized according to the adaptive approach, tools, which model and simulate future professional activity.

The technological approach (V. P. Bespalko, M. V. Klarin, O. M. Pehota, V. M. Monakhov, I. V. Sereda) is quite natural at ASIPPT, because it is precisely under the conditions of the information and educational environment that is implemented in the form of a hierarchical and ordered set of technological stages of designing the educational process, it is possible to achieve the planned result of the professional training of future specialists.

Taking into account the fact that the *student* -centered approach involves the use of teaching methods that shift the focus of education from the teacher to the student, ASIPPT studies the individual educational trajectory, develops and supports the individual educational program, and implements the individual educational route of the student. The ASIPPT implements the following principles of this approach:

1) the teacher should not be a lecturer, but he should be a facilitator, that is, a person who ensures successful group communication in the educational process;

2) the teacher must understand what help the student needs in terms of providing feedback in choosing an individual approach to choosing a learning model [166].

Therefore, the main provisions of the selected methodological approaches, complementing and enriching each other, act as the theoretical and methodological basis of the ASIPPT model.

Based on the analyzed scientific works on adaptive learning systems and fundamental works on adaptation, we determined the structure of ASIPPT.

Taking into account the extensive study of the problem of adaptation by representatives of various sciences (philosophy, sociology, pedagogy, information technologies, computing), we have identified three subsystems of ASIPPT:

1) essential – gives a general idea of the adaptive system being developed for the individualization and personalization of professional training of future specialists, its idea and concept;

2) pedagogical – involves understanding and presenting aspects related to the process of professional training of future specialists as an educational process;

3) instrumental – describes the instructive and flexible informational and educational environment of higher education institutions.

In the Concept, we adhere to the principles of modern didactics of higher education, which provide for the presence of organizational and pedagogical conditions that contribute to the improvement of the quality of professional education by forming the competencies of future specialists, necessary for successful future professional activity. ASIPPT, like any system, functions and develops under certain conditions, which are a set of measures aimed at realizing all the possibilities of the system. Identification of such organizational and pedagogical conditions is carried out in view of the analysis and evaluation of each task. Based on the content and essence of the concept, the following organizational and pedagogical conditions for the functioning of the adaptive system for the individualization and personalization of the professional training of future specialists under the conditions of blendededucation are highlighted:

1) Organizational:

a) creation and development of the information and educational environment of higher education institutions with an excessive amount of educational and informational resources;

b) providing opportunities for students to organize a personal (electronic) environment for individualizing their professional training;

c) material and technical equipment of professional training of future specialists with modern technical means of training;

d) wide use of information and communication technologies in the educational process of higher education institutions;

e) implementation of monitoring of professional training of future specialists.

2) Pedagogical:

a) use of the innovative potential of higher education institutions in the process of professional training of future specialists;

b) facilitative management of educational activities of students in higher education institutions;

c) taking into account the selected methodological approaches in the professional training of future specialists under the conditions of blended training of higher education institutions;

d) development and constant updating of educational and methodological materials and information resources to ensure professional training of specialists on the basis of adaptive training in higher education institutions;

e) use of appropriate forms, methods, means, methodical approaches and learning technologies to ensure individualization of students' education in higher education institutions;

e) involvement of students in self-awareness, self-learning, self-improvement, self-control, self-management;

g) the teacher's active position in improving his own professional qualifications and pedagogical skills.

Fulfillment of these conditions is aimed at improving the professional training of future specialists in institutions of higher education thanks to adaptive learning, individualization and personalization of education.

The concept of an adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended education defines the legal basis, fundamental theories, leading idea, goal, tasks, methodological approaches, organizational and pedagogical conditions for the functioning of the adaptive system for individualization and personalization of professional training of future specialists under the conditions of blended education teaching. System, adaptive, synergistic, cybernetic, environmental, individual, competence, activity, complex, technological and student-centered approaches are defined as the main methodological approaches. This will make it possible to design and develop an adaptive system for the individualization and personalization of professional training of future specialists under conditions of blended learning.

2.2. A model of an adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning

Various aspects of the problem of improving the professional training of future specialists have been studied by many scientists. As a result of a pedagogical search, researchers [73; 87; 201; 260] are increasingly inclined to the opinion that under conditions of great diversity of educational content and individual preferences of those who study, the educational process can be implemented in a higher education institution thanks to the implementation of adaptive learning systems. The work of many scientists is devoted to the modeling of such systems. In particular, M. Siadaty and F. Taghiyareh [260] proposed a model of an adaptive learning system based on consideration of learning styles. An adaptive learning system focused on learning styles and cognitive states was modeled by S. Chen and J. Zhang [54]. S. L. Huang and J. H. Shiu [103] developed a model of a user-oriented adaptive learning system, which uses sequential pattern analysis to build adaptive learning paths based on the collective intelligence of users to recommend adaptive materials, and also uses the theory of test tasks (Item Response Theory, IRT) with joint voting to assess students' abilities. H. C. Huang, N. Y. Wang and F. M. Hsieh [102] presented a model of an adaptive mobile learning system that provides learners with adaptive content according to their knowledge level, learning styles, and different learning devices. However, there is still an urgent need for modeling and development of a system in which adaptation technologies, approaches to individualization and personalization of education are applied in combination with the purpose of professional training of future specialists under the conditions of blended education at a higher education institution.

Modeling is used in pedagogical science to accurately reflect the properties of the phenomenon being studied, and the result is a model of this phenomenon. The model is a project of the educational process, which will later be implemented in practice, and will allow choosing the most effective ways to achieve the goal of training specialists [27].

In the process of modeling an adaptive system for the individualization and personalization of professional training of future specialists under conditions of blended learning (ASIPPT), we relied on scientific works

on the methodology of scientific research and pedagogy [98; 278], as well as modeling of pedagogical systems and environments [89; 272; 112].

The development of the ASIPPT model contributes to the study and provides new knowledge about the original object (a pedagogical process in an adaptive system for the individualization and personalization of professional training of future specialists under conditions of blended learning). In this aspect, modeling the pedagogical process in ASIPPT is necessary in order to learn how to manage this process; to determine the best ways of managing it under defined organizational and pedagogical conditions, goals and criteria; predict the direct and indirect consequences of the implementation of the specified methods and forms of influence on the subject (students of higher education institutions) with the desired result (professional competence); to provide technical capabilities of the process of professional training of future specialists in institutions of higher education; check the effectiveness and quality of professional training of future specialists in higher education institutions.

As a methodological basis for the construction of ASIPPT, we used a *polyparadigmatic* approach, which involves the use of an open cluster of approaches to learning that do not contradict each other, and their complex application has a synergistic effect. The leading role in this cluster is given to *the system* approach, taking into account the subsystems (substantive, pedagogical, instrumental) and their structure was designed.

The essential subsystem of ASIPPT.

The basis of ***the essential subsystem of the*** ASIPPT is a general idea of the adaptive system being developed, that is, how the concept and idea of its development will be implemented. Taking into account the fact that ASIPPT is implemented under the conditions of blended education, separate aspects of implementation of adaptation, individualization and personalization of education in the process of distance and traditional (face-to-face) education were highlighted (Fig. 2.1).

In ASIPPT, adaptive training is carried out by:

1) adaptation of educational materials (educational content) – organization of algorithms for adaptation of educational materials in a three-level system: "introductory adaptation" (adaptation of the content of introductory materials of the discipline based on the initial level of students); "current adaptation" (adaptation of educational materials based

on the current productive actions of students in an adaptive electronic environment (AED)); "evaluative and corrective adaptation" (adaptation of normative parameters of the level of mastery of materials taking into account the educational results achieved by students) [307];

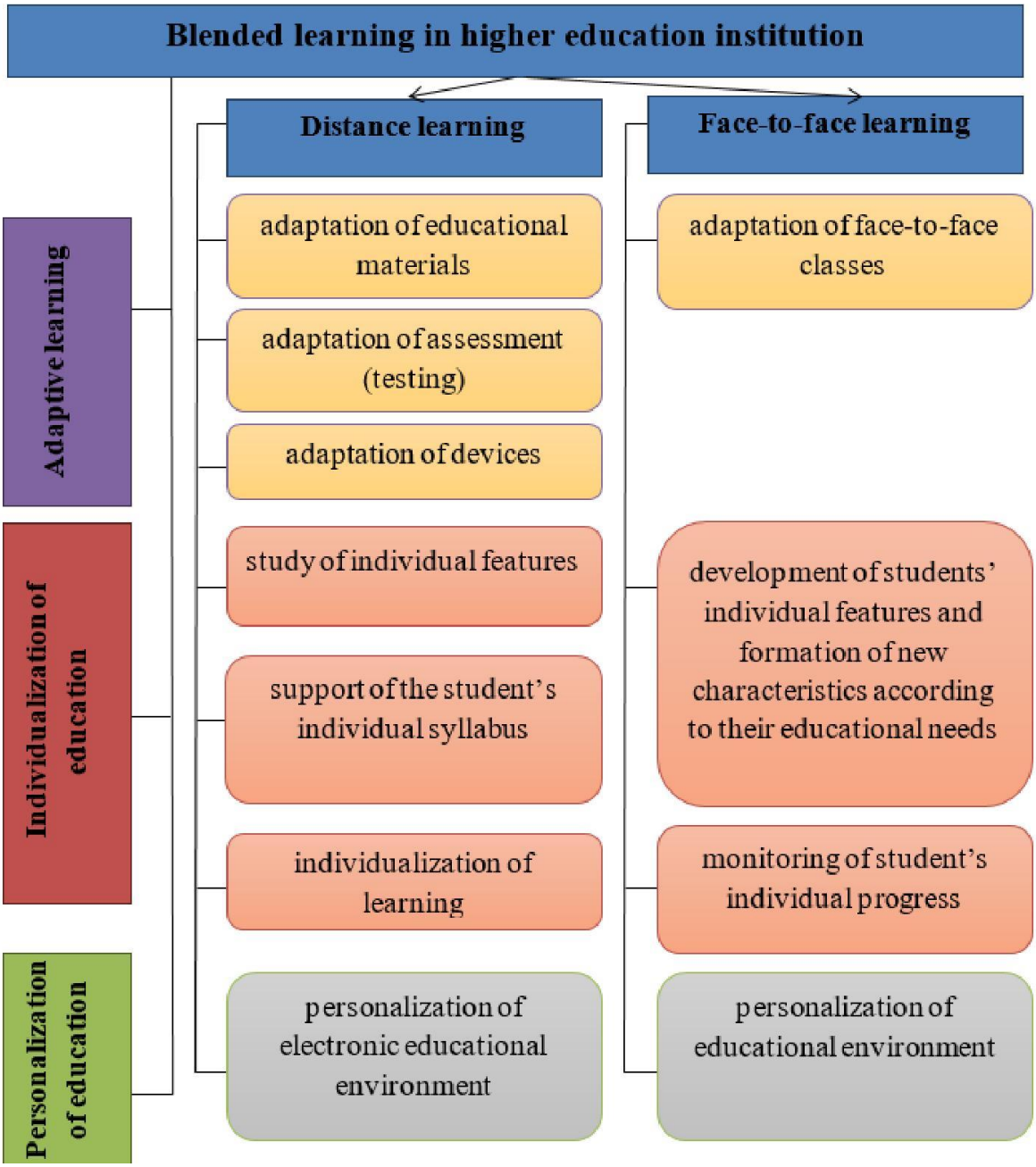

Fig. 2.1. The essential subsystem of ASIPPT

2) adaptations of control (testing) – methods of adjusting the complexity and number of proposed tasks are used, depending on the answers of the learner, including various testing options: pyramidal (everyone is given a task of medium difficulty and only then, depending on the answer, everyone is given a task that is easier or more difficult), flexible testing

(starts with the level of difficulty chosen by the test-taker, with a gradual approach to the real level of knowledge), stratified (carried out using a bank of tasks divided by levels of difficulty: if the answer is correct, the next task is taken from the upper level, if incorrect – from the bottom) [75];

3) adaptation of devices – adaptation of educational resources (portals, SDN, sites, etc.) to various computer devices (PC, mobile phones, smartphones, tablet computers) [102].

4) adaptation of face-to-face classes – new class structures are created during classes, training is varied (content, forms, methods, tools) and the educational process is adapted to the individual characteristics of students thanks to a significant increase in the time for independent work of students, work in pairs and small groups; the individual pace of students' work depending on the level of knowledge and skills, natural endowments, work capacity, etc.; creation of multi-level tasks for independent work; providing students with a choice of the level of complexity of the tasks to be performed; wide use of generalizations and reference schemes in education; management of the educational process using a network plan; continuous and continuous control of the results of independent work [7].

At ASIPPT, the individualization of education gives the student the opportunity to independently form a plan, content, pace and time of education from the list of educational resources, focusing on personal preferences, and to work according to an individual educational program.

Within the framework of ASIPPT, the following ways of individualization are planned:

1) the study of individual qualities of students – at the beginning of training, a number of psychological and pedagogical measures are carried out, which are the basis for determining the individual educational trajectory of the student and analyzing the results with the aim of taking them into account in the process of professional training (for example, determining and offering study time, depending on psychological characteristics student);

2) support and support of the student's individual educational program – considering that individualization involves the organization of a system of interaction between participants in the learning process, in which the individual characteristics of each are most fully used [99], the system provides for the digitization of acts of communication (their recording, algorithmization, timing, archiving) and monitoring of competencies,

including educational and professional self-determination and self-presentation (professional portfolio) [163];

3) individualization of the learning process – in the process of implementing an individual educational route, the opportunity to learn at a time convenient for the student and at his own pace (faster, slower, flexible deadlines for reporting) is realized;

4) the development of the individual characteristics of the student and the formation of new characteristics according to his educational request – involves the implementation of "subject-subject" training based on the individualization of the student, when such necessary qualities as independence, initiative, creativity, confidence, enthusiasm are developed and formed, a research style of activity, a culture of search and work, that is, those qualities that are so necessary for a future specialist who will operate in new social conditions [99].

5) monitoring of the student's individual progress – a step-by-step creation by the student of his own professional portfolio, which reflects the results achieved by him in the process of professional training in a certain specialty without comparison with the achievements of other students.

In ASIPPT, the personalization of training ensures the growing demand of users (those who study) to satisfy the desire for an individual approach to personal requests, which is natural for human nature, and the need for greater productivity and comfort in the work of mastering new competencies [45]. Teachers turn to personalization in order to intensify and increase the efficiency of the process of professional training of future specialists.

Personalization of training at ASIPPT is carried out in two ways:

1) personalization of the electronic educational environment (PEOS);

2) personalization of the educational environment.

PEOS provides for the creation of conditions for the consolidation of various Internet services, electronic resources and ICT tools in their interconnections, thanks to which the student builds his own educational process, including the personalization of the SDN interface (depending on the results of testing individual characteristics, the proposal of the color scheme of the student's personal page in the SDN). Access to learning becomes access to resources and services and allows students not only to use learning resources, but most importantly – to create them. Learning in this

way is transformed from the transfer of information and knowledge to their creation [176]. A personal electronic educational environment is formed by a set of open educational resources, web services and software applications that must perform certain tasks or functions in the educational process, which is described in more detail below in the instrumental subsystem.

Personalization of the educational environment involves the creation of conditions for students to organize their own set of educational resources (teaching aids) in the laboratories of the higher education institution. This becomes possible thanks to the creation of a STEAM laboratory at university. The space of the laboratory is made in the format of makerspace (Makerspace) – the world format of creative spaces-workshops – as a place for implementing ideas, conducting experiments, studying, applying in practice and improving new skills of students [113]. Teachers and students have the opportunity to come to the laboratory to use special equipment, which is quite specific in its characteristics. The space of the laboratory was planned in a certain way with the aim of expedient and comfortable accommodation and work of its visitors, ensuring mobility, flexibility and the possibility of using technical means in education. Equipping the STEAM laboratory allows you to create optimal conditions for the realization of the potential opportunities of each student in order to organize his personal educational environment in higher education institutions.

Pedagogical subsystem of ASIPPT

The main features of ASIPPT are its divisibility, which implies the possibility of separating its constituent components, and structurality, since any system has a structure that is a set of connections between parts of the whole [197]. ***Pedagogical subsystem*** of ASIPPT provides for the understanding and presentation of aspects related to the process of professional training of future specialists as an educational process. This subsystem, like most pedagogical models of education as a unity of process and result, contains five *components*: target, theoretical-methodological, content, activity, result. We added a creative component to the traditional components of the pedagogical model, because in our opinion, educational systems should develop the creativity of future

specialists, which contributes to more effective assimilation of professional competencies by students (Fig. 2.2).

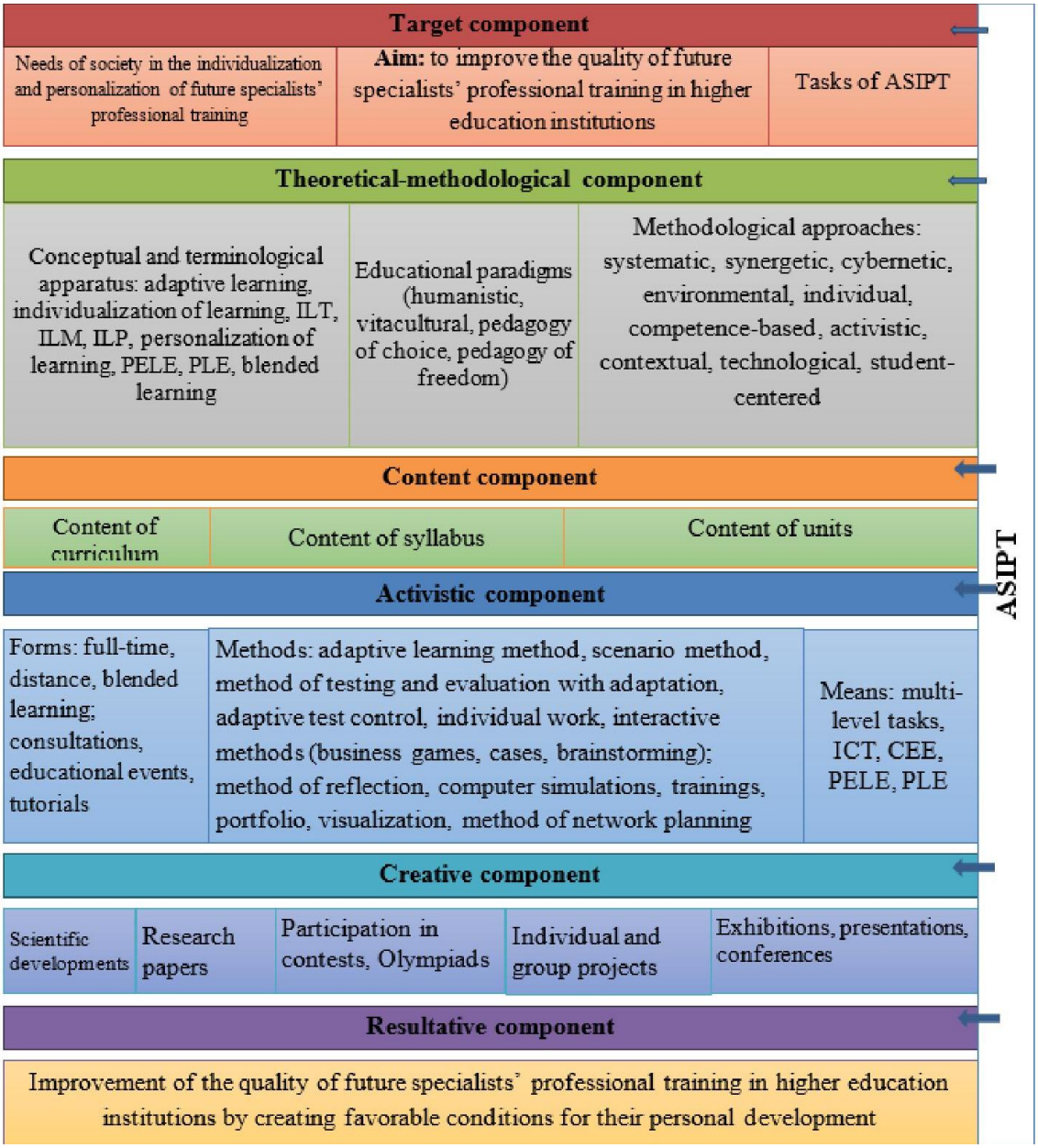

Fig. 2.2. Pedagogical subsystem of ASIPPT

The target component determines society's needs for individualization and personalization of professional training of future specialists; the goal of improving the quality of professional training of future specialists in institutions of higher education by creating favorable conditions for their personal development; tasks of ASIPPT.

The theoretical-methodological component reveals the conceptual-terminological apparatus, educational paradigms and methodological approaches (systemic, synergistic, cybernetic, environmental, individual,

competence-based, activity-based, contextual, technological, student-centered), on which ASIPPT is built.

Content component reflects the content of the professional training of future specialists in the form of an educational professional program, developed on the basis of the standard of higher education for the training of bachelors and masters; the content of disciplines organized in accordance with the requirements of adaptive learning, including the selection of content (didactic) units in each discipline.

The activity component determines the system of forms, methods and means and organizational and pedagogical conditions that contribute to the improvement of the quality of professional education by forming the competencies of future specialists necessary for successful future professional activity.

The creative component involves the development of students' creative abilities in innovative pedagogical activities, their involvement in the development of new projects, writing scientific papers, participation in competitions, Olympiads, exhibitions, presentations, conferences, etc.

The effective component determines the improvement of the quality of professional training of future specialists in institutions of higher education due to the creation of favorable conditions for their personal development.

All components are interconnected through ASIPPT.

Instrument subsystem ASIPPT.

To implement adaptation, individualization and personalization of education, this environment is created by using various tools: information and communication technologies, modern technical means of education, hardware and software. These tools form ***an instrumental*** ASIPPT ***subsystem.*** Its schematic representation is presented in Fig. 2.3.

The basis for this subsystem is the learning management system (LMS) Moodle. It is not positioned by the developers as an adaptive learning system, but the growing popularity of adaptive learning technology has prompted Moodle developers and other programmers to improve it. Therefore, appropriate plugins have been developed to implement an adaptive approach in Moodle. Among the analyzed plugins, we singled out Adaptive Quiz for test adaptation, IADLearning for content adaptation, and a stack of plugins (Learner preferences, Learner adaptation, Navigation Web) for navigation adaptation [196].

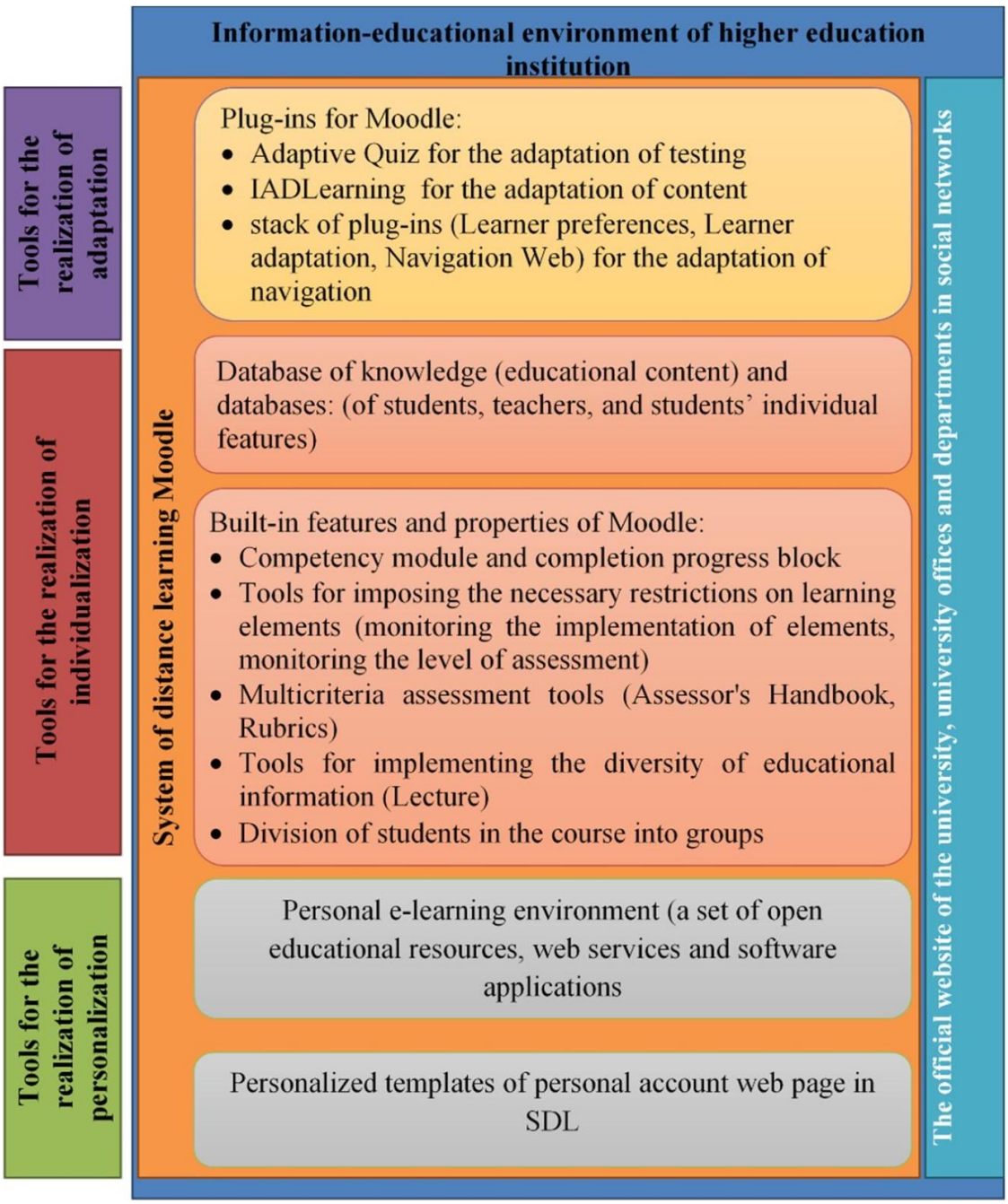

Fig. 2.3. Instrument subsystem ASIPPT

LMS Moodle has the following advantages to support the individualization of training: creation of a discipline course in the form of a modular structure; formation of modules with the availability of material based on the results of studying previous modules and passing intermediate tests; creation of educational materials of a branched structure according to a previously created pedagogical scenario (lecture with feedback); creation of resources with additional opportunities to process the material for students with weak preparation; creation of multilevel tests; creation and placement in the course of individual tasks [88].

The easiest way to individualize the study of a discipline is to create mini-groups in the SDN to optimize the path of their educational process. Creation of tasks and educational materials for groups depending on the initial level, educational features and tasks set to achieve the goals. Addition of additional materials to the course that master in-depth and extended material. In addition, it is convenient to support the development and implementation of project activities in LMS Moodle.

Integration of LMS Moodle is possible with various information systems, which allows you to create and save a student's electronic portfolio, where all submitted work, evaluations and comments of the teacher, messages in the forum are stored.

LMS Moodle offers the following tools to implement an individual approach:

1) Tools for forming a learning route by imposing the necessary restrictions on learning elements (tracking the execution (review, study) of an element, tracking the level of assessment).

2) Multi-criteria evaluation tools (Evaluator's Handbook, Rubrics), which takes into account the complexity of the material.

3) Tools that allow you to implement the multivariate presentation of educational information within the framework of a single distance course.

4) Formation for each group of listeners of its profile of presentation of educational material.

Individualization of the learning process using Moodle can be expanded at the expense of mobile learning technologies [203]. They can be used as an additional line of education in educational institutions [231]. This is achieved through various mobile technologies. In particular, for the implementation of individual training, in addition to accessing Moodle through a mobile phone browser, there is a Moodle mobile application in the App Store and Google play, which has a convenient interface and full functionality for students to work with a distance course.

For the organization of a personal electronic educational environment (PEOS), it is advisable to use appropriate tools. It should be noted that other tools from other vendors and Internet service providers can be used as examples of tools in PEOS. We have outlined only examples, based on our expert experience of working with ICT (Table 2.1).

Table 2.1. A toolkit for organizing a personal electronic educational environment at ASIPPT

The task, the function of the toolkit	Type of tools	Example of tools
Organization of a single point of entry	Educational portal	Official website of ZVO, Google Apps for Education
Organization of training	Learning management systems	Moodle, Google Classroom, Blackboard Learn
Publication of educational materials	Services for creating electronic courses	Edmodo, Eliademy
	Video hosting	YouTube
	Online presentation services	Prezi Google Slides
	Photo hosting	Google Photos, Imgbb
	Services for publishing documents	Google Docs
Development of practical skills	Virtual simulators	Codecademy, GeoGebra, STAR, Classmaster, PhET
Cooperation	Services for joint work on documents Online boards Online mind maps Services for organizing work in teams Services for project management	Google Docs Twiddla, Miro, IDroo MindMeister Trello, Asana CRM B itrix 24 Wrike, Basecamp
Communication	Messengers Applications for group calls Video conferencing services	Viber, Telegram Discord Skype Google Meet, Zoom,
Systematization and preservation of data and information	Cloud data storage Note saving services Services for collecting and systematizing information	Google Drive, Dropbox, Evernote, Netboard Pinterest
Presentation of learning results	Services for creating sites Portfolio services	Google Site, Wordpress.com Behance.net, Clippings.me
Search for educational resources	Search services	Google Search, Google Scholar, Google Maps
Information about events at the university	Pages in social networks	Facebook, Instagram, Twitter, TikTok, LinkedIn

General model of an adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning.

The presented models of three subsystems of ASIPPT can be summarized in one model of ASIPPT (Fig. 2.4).

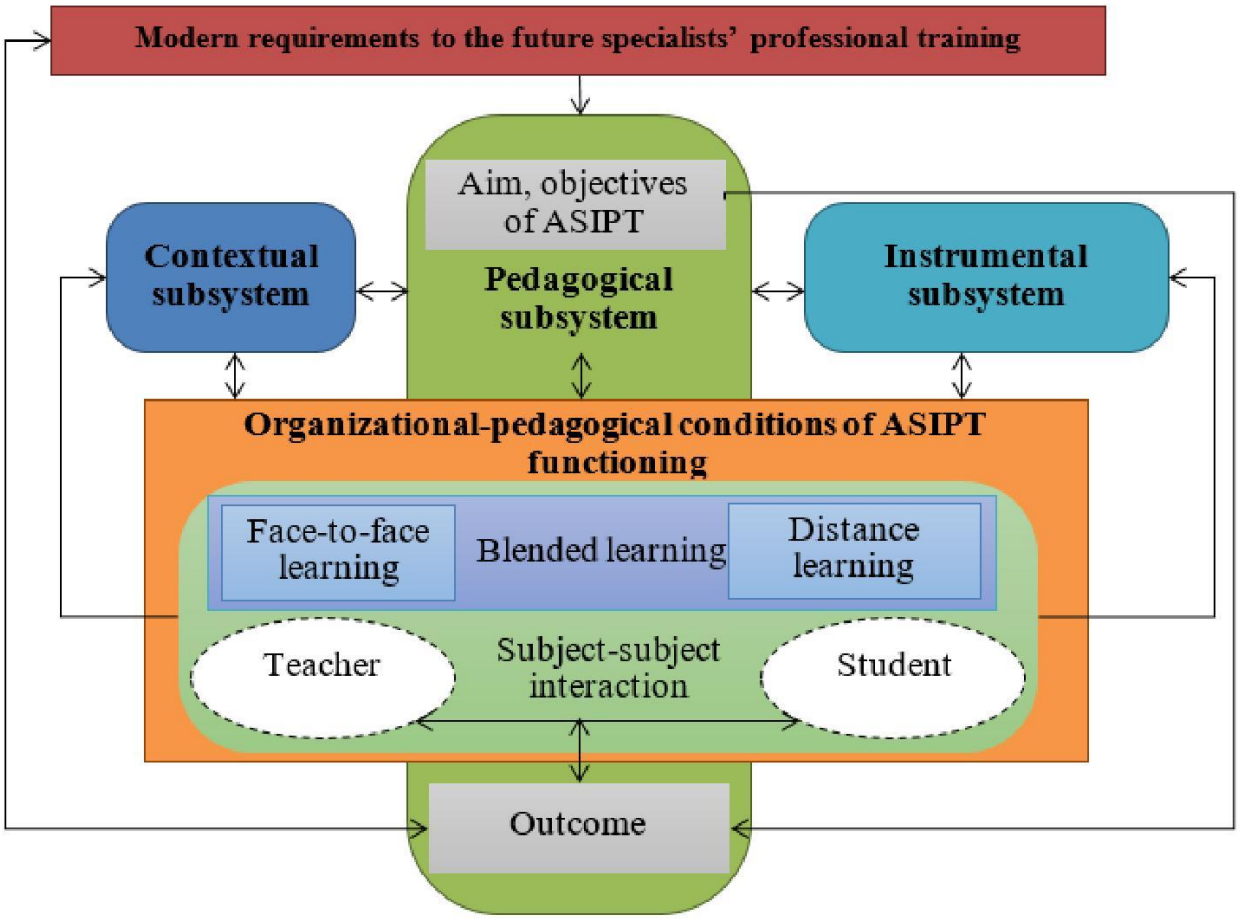

Fig. 2.4. A model of an adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning

The developed model of ASIPPT as part of three subsystems (substantial, pedagogical, instrumental) provides for taking into account modern requirements for professional training of future specialists, which is consistent with the purpose and result of its implementation. All subsystems are interconnected and conditioned by the organizational and pedagogical conditions of the functioning of the ASIPPT, the leading ones of which are the conditions of blended learning and subject-subject relations between the main participants of the educational process (teacher, student).

In the modeled adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning, adaptability is planned to be implemented by adapting educational materials (content of educational content), control (testing), devices, face-to-face classes; individualization – study of individual qualities of students, support and accompaniment of the individual educational program of the student, individualization of the learning process, development of the individual characteristics of the student and the formation of new characteristics according to his educational request, monitoring of the individual progress of the student; personification – the organization of the educational environment, including the electronic one. The further development of the research is the development of a working prototype of an adaptive system based on a stack of educational and information and communication technologies implemented in a higher education institution.

2.3. A model of blended learning in a higher education institution: development, implementation and research

Nowadays higher educational institutions are forced to adapt to the rapid changes in society and the challenges which are connected with economic, social, cultural and epidemic problems in the world. It is also important for higher educational institutions to stick to the student-centered education, to meet the students' needs for quality education, despite natural and social cataclysms. Today, in the context of digital transformation [214], the training of future professionals is undergoing appropriate changes in the organization of educational activities and interaction between the subjects of the educational process due to the development of distance and blended learning technologies, which became especially important during the Coronavirus pandemic [195]. Thus, according to the conclusion of the G2R research group, online learning has become a safe and viable option for the continuity of education, since the COVID-19 pandemic has turned the personal and professional world upside down [36]. The development of distance learning technologies contributes to the diversification and spread of blended learning, which is considered the best for learning and teaching in general educational institutions [156] and higher education [252]. At the same time, the issue of choosing a blended learning model in a higher education institution requires a separate study. After all, it is necessary to choose the most successful and appropriate organization of blended education, taking into account the peculiarities of the educational institution and the experience of implementing digital education in it. Such a task involves the analysis of existing models of blended learning, their modification or the development of one's own model for the organization of blended learning in a higher education institution and evaluation of the results of the implementation of the developed model.

The issue of modelling and implementation of blended learning in higher educational institutions to maintain efficient professional training of students are considered by C. Andersson, P. Appiah-Kubi, N. Balyk, E. Basile, N. Kushnir, L. Kuzmich, D. Logofatu, S. Lytvynova, M. McCabe, V. Oleksiuk, N. Osypova, C. Şentürk, O. Spirin, S. Sydorenko, N. Valko, K. Zouhri and other researchers.

C. Şentürk [252] presents results of examination how a blended teaching-learning approach affects academic achievement and twenty-first century skills of preservice teachers who take the teaching principles and methods course at university. He gave generalized blended learning model which is the crossing of face-to-face learning and virtual learning. The researcher found that the blended learning experiences had a high level of impact on students' long-term learning and their twenty-first century skills.

P. Appiah-Kubi et al. [8] describe the study which was initiated to learn about the level that Engineering Technology students engaged with online course materials using Zoom and Learning Management System. Researchers point out that Engineering Technology programs incorporate a lot of laboratory and hands on modules. So, it is necessary to ensure that students stay engaged in learning by doing despite restrictions of online mode. They found that students who performed better in the blended courses demonstrated a higher level of engagement with course materials.

O. Spirin et al. [267] consider a cloud-based approach to blended learning of computer networks. Their teaching technique is to use an integrated academic cloud, which includes Apache CloudStack and EVE-NG Community platforms, to support work in groups. Researchers discuss some techniques of blended learning: combination of face-to-face and distance learning, group members' partnership, development of group work skills, heterogeneous grouping, combined use of individual and peer assessment, teacher's monitoring of the students' work, task-oriented approach, chance for every member to be a leader, essential feedback. Results of their experimental work show that blended learning allows teachers to use the technological benefits of academic cloud to achieve the study goals more efficiently.

An approach to development of an instructional design model for mobile blended learning in higher education is described by I. K. Suartama, P. Setyosari, S. Sulthoni, and S. Ulfa [276]. Researchers created mobile blended learning design for university Instructional Media Course aimed to students get the knowledge and skills in the field of design, development, utilization, evaluation, and assessment of media in learning. Developed model is presented like a matrix, which consists of learning objectives, stages

of learning and features of mobile app of Moodle LMS. Researchers formulate 8 learning objectives based on the learning objectives of the revised Bloom taxonomy. They think there are 3 stages of blended learning: 1) before class (online); 2) in the class / onsite (offline); 3) after class (online). So, they offer activities for each learning objective and each stage.

A. Adel and J. Dayan in [2] describe a design for a system of blended learning activities for New Zealand institutions. This is a total learning model, which blends digital technologies with traditional learning. Its central point is social media site where all other components (introductory session; e-learning; classroom instruction; virtual support) are linked together.

Wahjono et al. [316] present a model of blended learning based on semester credit system implementation. It combines three main stages, namely, planning, organizing, and teaching-learning process. A planning stage includes in particular student’s admission, program selection, class grouping. An organizing stage includes in particular preparing for guidance documents, basic competence analysis, and mapping, management system development. The third stage includes in particular preparing the teaching and learning documents, the teaching and learning process, assessment, collaborative coaching, reporting on the learning process. All of these stages are supported by computer software. Authors illustrate their model with detailed flowcharts, which let to understand processes on all stage.

Therefore, there are various approaches to modeling the blended educational process, which depends on the conceptual views of the authors, the characteristics of the certain educational environment, and the general cultural characteristics of the country. It can be argued that there is no single version of such a model, therefore it is appropriate to develop an author's approach to solving this problem.

The concepts of "blended learning" [267] and "hybrid learning" [168] are found in scientific studies. In order to solve the problem of the correct use of the term, we analyzed the relevance and usage of these terms in English and Ukrainian during the last five years according to the indicators of the Google Trends service. According to Google Trends, neither the English-language term "hybrid learning" nor the Ukrainian-language "hybrid education" is widespread in Ukraine [194]. Therefore, it is advisable

to focus on the concept of "blended learning", which we understand as a kind of hybrid methodology, when there is a combination of traditional (offline learning, in classrooms, face-to-face), online and independent learning [229]. It is not just the use of modern information and interactive technologies in addition to the traditional ones, but a qualitatively new approach to learning. Visually, it can be represented as follows (Fig. 2.5).

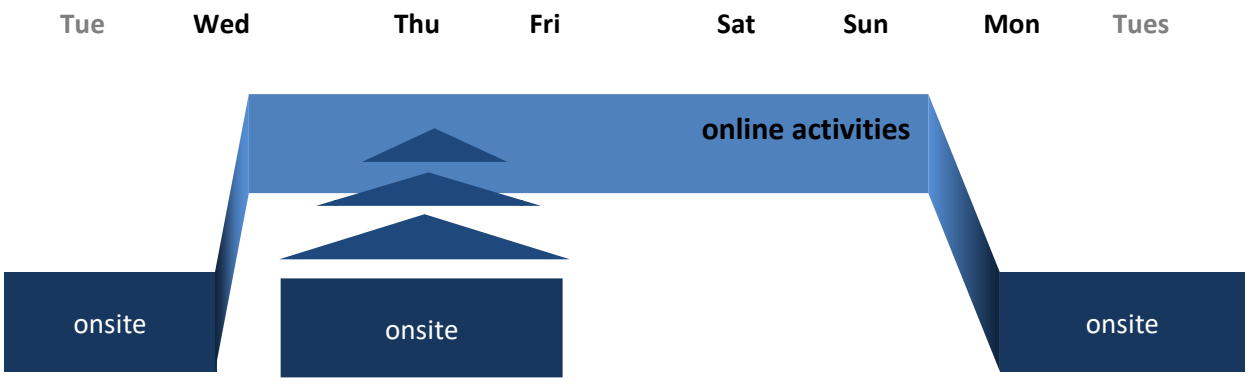

Fig. 2.5. An example of movement in blended learning (source [270])

According to the sequence of actions in the learning process, distance and training models of blended learning are distinguished [30].

1. The first "distance" model – learning process is taking place according to the following scheme (Fig. 2.6):

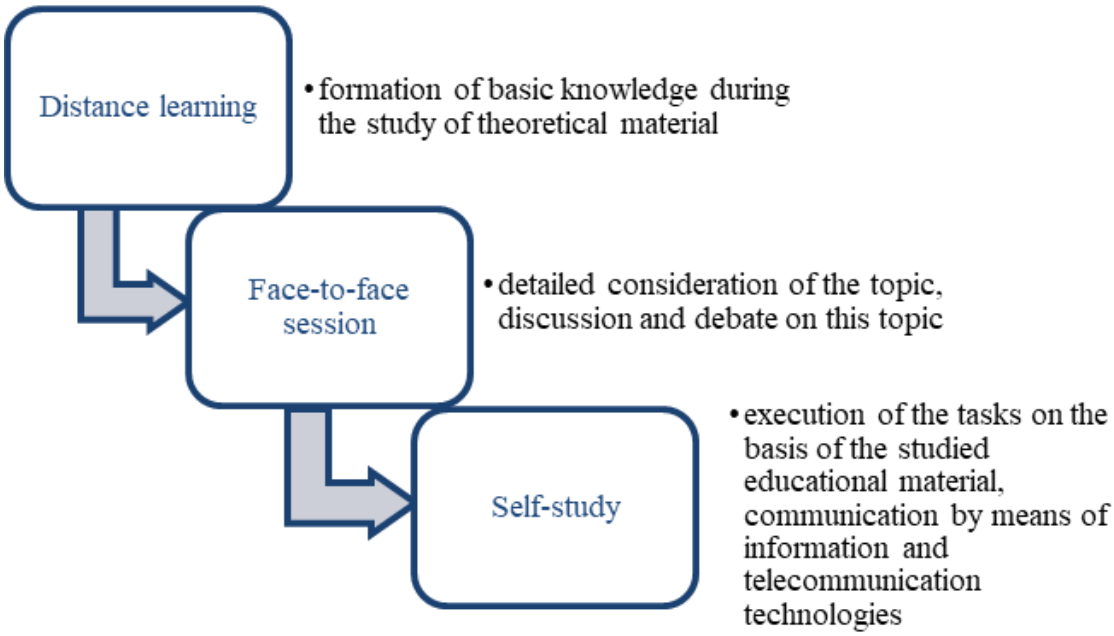

Fig. 2.6. Distance model of blended learning

2. The second "training" model is implemented according to another scheme (Fig. 2.7):

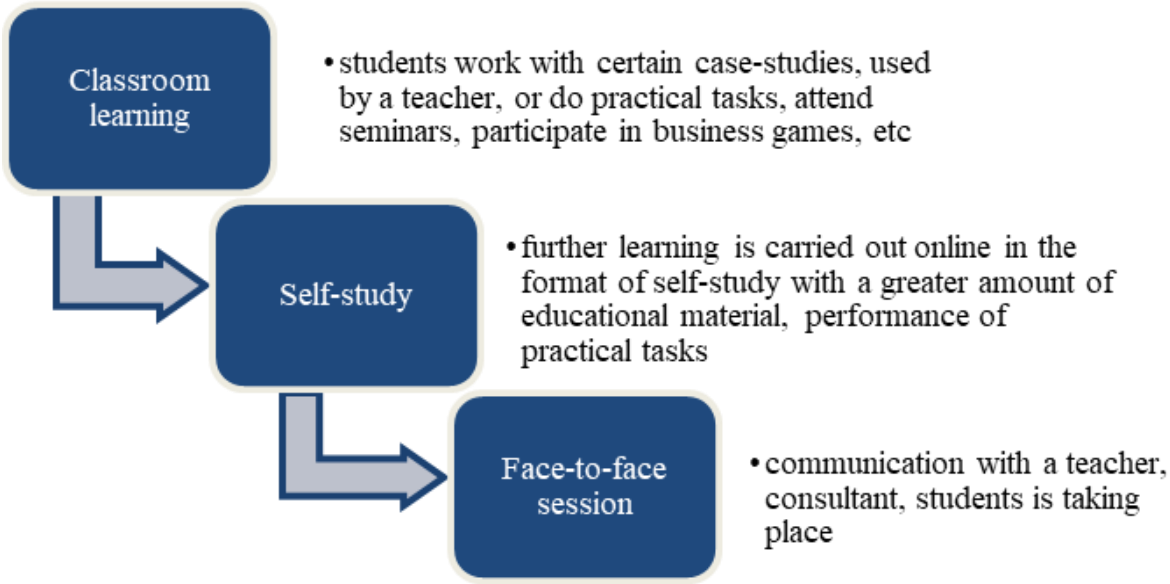

Fig. 2.7. Training model of blended learning

According to another approach, the following models of blended learning are distinguished:

1) Rotation model is a program in which within a given course or subject (e.g., math), students rotate on a fixed schedule or at the teacher's discretion between learning modalities, at least one of which is online learning.

2) Flex model is a program in which content and instruction are delivered primarily by the Internet, students move on an individually customized, fluid schedule among learning modalities, and the teacher-of-record is on-site.

3) Self-Blend model describes a scenario in which students choose to take one or more courses entirely online to supplement their traditional courses and the teacher-of-record is the online teacher [268].

The analysis of the existing models of blended learning suggests that none of them can be implemented without changes in the process of professional training in higher educational institution. Therefore, our aim was to identify an effective model of blended learning that would work adequately in Ukrainian higher educational institution.

It should be noted that in Ukraine the implementation of blended learning in the real conditions of higher educational institution's work is determined and limited by the requirements for the educational process set

by university authorities and the Ministry of Education and Science of Ukraine.

The experience of implementing blended learning [194] and distance learning technologies [314] allowed us to form a model of blended learning with an orientation to the sequence of actions.

In general, in the process of professional training in a higher education institution, the following sequence of actions takes place: Face-to-face lectures → More detailed distance learning of theoretical material → Face-to-face practical classes → Self-study of practical tasks at home, Work with additional online materials → Automated testing (in the classroom or distantly) → Self-study of the materials or online self-study tasks → Face-to-face or distance assessment of the level of knowledge (Fig. 2.8).

The cycle of theoretical and practical educational material learning along with automated testing and online self-study is repeated as many times as it is needed for a comprehensive mastering of the discipline according to the syllabus of the discipline. Then the assessment of the level of knowledge takes place usually in the form of exam or test.

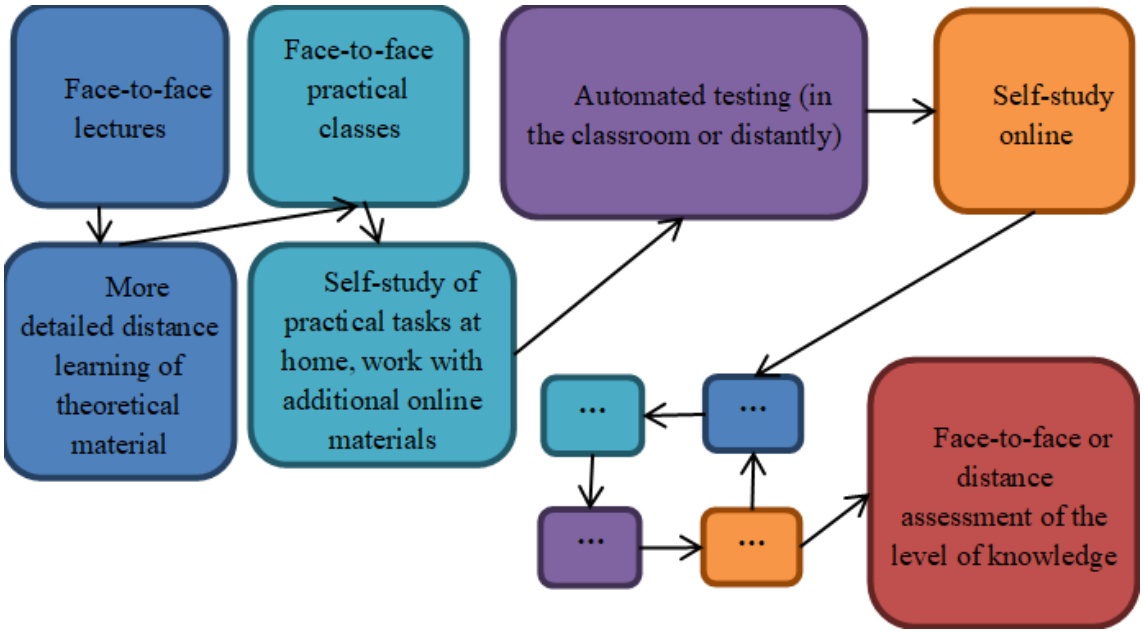

Fig. 2.8. Generalized model of blended learning in the higher educational institution

It should be noted that not all processes take place sequentially, and some of them may take place simultaneously, depending on the pace of work of individual students and the tasks they choose in the process of studying

a particular discipline. This is a main feature of the individualization of the learning process: each student can choose their own learning path, duration of learning through online learning tools, time to study theoretical material or develop practical skills, as well as a convenient time to do the tests in order to demonstrate learning outcomes. One student may feel that it is enough to have face-to-face classes (as it was proved by the results of automated testing), and others may find it more convenient to learn everything online. Thus, the model is variable and can be adjusted to the needs and preferences of students.

The important feature of the quality of organization of blended learning model is the responsibility of a teacher for the excessive filling of the e-learning environment, used in the process of blended learning in higher educational institution, with teaching materials, practical tasks and additional resources. Most often, educational institutions use the Moodle platform [151] is used for this, and distance courses are developed on it.

During 2 semesters in Bogdan Khmelnitsky Melitopol State Pedagogical University the 1st-4th year Bachelor students and the 1st-2nd year Master students of specialties 015.39 Vocational Education (Digital Technologies), 014.09 Secondary Education (Informatics) and 122 Computer Science were taught the disciplines of the professional cycle according to the developed generalized model.

After the introduction of lockdown and the start of global use of distance learning technologies in the learning process, students were interviewed about the use of blended and distance learning technologies. The purpose of the survey was to find out students' attitudes towards these technologies. The survey was conducted on a voluntary basis using Google Forms. 74 students (27% of them were Master students and 73% – Bachelor students) took part in the survey.

Analysis of the survey results allows us to draw the following conclusions and generalizations. Almost all students (91.9%) have an idea of what blended learning is and all students are acquainted with distance learning technologies provided by means of Internet technologies (100%). It has to be mentioned that the vast majority of students believe that blended learning is a combination of online learning, traditional learning and

self-study, which largely confirms the claim that they are aware of this technology.

The aim of next block of questions was to find out how students understand the difference between the use of distance learning elements in process of face-to-face learning and the full use of distance and blended learning technologies during the lockdown. It turned out that before the lockdown 54.1% of teachers used blended learning in their teaching and 41.9% of them used distance learning. And during the lockdown, the percentage of such teachers increased to 90%.

The aim of the third block of questions was to find out students' attitudes towards traditional, blended and distance learning, as they were able to get to know the differences between them through measures taken during the Coronavirus pandemic. Researchers were particularly interested in the issue of the diversity of learning process. The answers of the respondents were as follows: 1) 40.5% of students believe that during distance learning the communication was better, 35.1% – consider the communication to be better during traditional learning, 24.3% pointed to the blended learning; 2) 60.8% of respondents noted that they received the best grades during distance learning, 25.7% – during traditional learning, 13.5% – during blended learning; 3) traditional education fully satisfies only 29.3% of students, distance learning – 37.8%; blended learning – 44.6%; 4) traditional learning is considered to be of better quality – 38%, distance learning – 23%, blended learning – 45%.

The aim of the fourth block of questions was to find out how students perceive the learning process organized on the basis of the proposed generalized model of blended learning. Among the advantages of such learning, students singled out the following: accessibility (learning materials are available anytime and anywhere) – 60.8%; digitization (work mainly with digital resources) – 55.4%; productivity (you can choose the time, place and pace of learning) – 52.7%; consideration of students' individual needs (it allows students to learn at their own pace) – 48.6%; communication (opportunities to communicate with the teacher and other students anytime and anywhere) – 47.3%; independence (independent identification of what, when, how and where to learn) – 44.6%; collectivity (is provided by a variety

of content types) – 29.7%; interest (it is more interesting to learn in such a way) – 27% (Fig. 2.9).

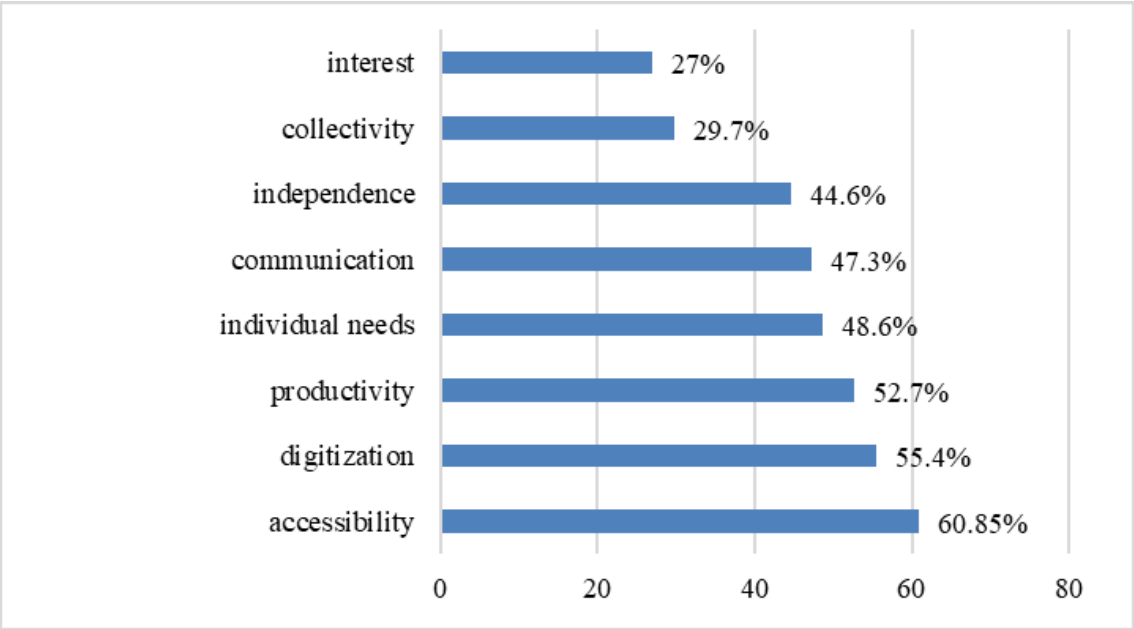

Fig. 2.9. Advantages of blended learning according to students

So, 48.6% of students stated that they would be able to study well in the process of blended learning, 37.8% – neither agree nor disagree, 13.5% – believe that they will not be able to study well in the process of blended learning.

Among the reasons that prevent students from participating in blended learning, the respondents chose the following: motivation to study – 28.4%; lack of confidence in achieving academic success – 27%; Internet quality – 23%; absence or the computer or when it is out of date – 12.12%. Therefore, it can be concluded that there are no reasons related to the organization of blended learning according to the proposed model. In addition, 44.6% emphasized the absence of reasons preventing them from participating in blended learning.

The survey allowed us to find out what technologies students and teachers use when organizing blended learning by means of information and communication technologies: video telephony programs (Discord, Zoom) – 94.6%; e-mail – 77%; distance learning platforms (Moodle) – 85.2%; messengers (WhatsApp, Viber) – 59.5%; teamwork services (online boards, online documents) – 47%; educational websites – 43.3%; video hosting (YouTube, Youku, Tudou, meWATCH) – 27%; social networks (Facebook,

Instagram) – 13.5%; microblogging (Twitter, Tumblr) – 2.7%; virtual reality – 1.4%. Such responses indicate that despite the popularity and rapid spread, virtual reality technology has not yet become sufficiently widespread in the organization of distance learning. Respondents also noted that the assessment of learning outcomes was carried out mainly in the following ways: submitting the completed tasks by e-mail to the teacher – 43.2%; automated testing – 24.3%; online conferences – 18.9%. Almost all students are satisfied with taking their exams distantly – 95.9%.

The following feedback was received in the comments to the survey:

Blended learning is appropriate, especially under the conditions of lockdown restrictions and if it sticks to the individual learning plan.

I really like blended learning because the time is not wasted.

Per-to-per learning allows us to develop communication skills.

Many employed students do not always have time for blended learning.

Distance learning is better than blended learning.

This is a better option for distance learning.

During blended learning I am more focused, and after it I am less tired, it is comfortable and convenient.

It is easy and provides the opportunity to choose time to execute the tasks.

Although traditional learning allows you to communicate with teachers "face-to-face", but the teachers of MSPU offer quality materials in various formats.

It was clear that some teachers and group mates were not satisfied with this form of education, not all effectively taught and studied distantly, but as for me it was quite easy and comfortable to do most of the courses.

Therefore, the majority of students positively evaluated the experience gained during blended learning based on the proposed generalized model. At the same time, there were separate critical reviews, for example: "Many employed students do not always have time for blended learning," "Distance learning is better than blended learning." In our opinion, this is caused by the following factors: some students did not sufficiently understand the peculiarities of blended and distance learning; a number of students were focused specifically on distance learning, so other forms of education were

perceived critically. This encourages us to improve the model and determine more effective ways of its implementation.

The results of the survey are valuable, taking into account the fact that during their university studies students had the experience of learning in traditional, distance and blended learning modes. This allowed us to draw more reliable conclusions from the research of the results of the implementation of a blended learning generalized model in higher educational institution, which is not limited to only two modes of learning.

Analysis of the research on the implementation of blended learning in higher educational institutions allowed us to identify 2 models of blended learning according to the sequence of actions in the learning process and 6 models from the point of view of students. Taking into account the conditions of organization of education in higher educational institutions of Ukraine and our own experience in the implementation of blended and distance learning, our own generalized model of blended learning in higher educational institution has been proposed. The model is a variant of a consistent model of blended learning and is aimed at in-depth study of educational materials taking into account the individual needs of students for the organization of their learning activities. The study of the results of the implementation of the generalized model of blended learning was carried out by means of doing a survey and analyzing its results. It allowed us to prove the positive attitude of most students to the implementation of blended learning on the basis of the proposed model.

2.4. A functional learning model based on a combination of augmented and virtual reality technologies with adaptive learning systems

The modern world is causing changes not only in the fields of economics and technology, as well as changes in the level of future students prior training, their needs and expectations. As a result, the education strategy is changing too. Virtual and augmented reality (VR and AR) technologies are the means of a fundamentally new level of human interaction with the digital world, which are playing an increasing role in the global economy, politics, social relations etc. The symbolic information world offers a wide range of ready-made patterns and styles of behavior that people choose and try to implement in their daily lives. Today, these samples are represented primarily by computer virtual reality, virtual (computer) symbolic world, which provides the subjects of information space different motivational, cognitive, communicative, operational, creative, spiritual opportunities [298, p. 25].

Virtual and augmented reality technologies have got the most serious development in the entertainment markets. This is not the limit, but only the first stage of their implementation. Products based on virtual and augmented reality technologies are promising in terms of economic effect in the fields of industry, health care, consumer services, and education. The variety of companies and institutions of higher education implementing augmented and virtual reality technologies testifies to the prospects of this technology. In particular, the Japan Online School VR was recently opened in Japan by the private institute Meisei High School [251]. Learning with AR and VR technologies could be considered a new way of knowledge transfer that corresponds to a qualitatively new content of learning and personal development of students, stimulates innovative aspects of teachers activity and creates preconditions for the implementing new approaches to learning and improving education. Augmented and virtual reality technologies are a new way of presenting information, making it much more visual and attractive. Their use helps to increase students' motivation in learning process through clarity, information completeness, interactivity and gamification of education.

Some issues of design, development and application of educational software and simulators based on augmented and virtual reality technologies are considered in a number of scientific works, namely: the potential of augmented reality to transform the educational process into smart learning [127]; general issues of augmented reality software development for educational purposes [285]; application of virtual reality in education [206; 310]; prospective analysis of the application of augmented reality technologies for the training of specialists of the new technological era [108]; the issue of using computer simulations and games in engineering education [64]; problems of using virtual reality in foreign language education in institutions of higher education [283]; the issue of developing an educational simulator with augmented reality for studying algorithms [136]; peculiarities of using a virtual environment for training specialists in information technologies [254].

Application of adaptive learning systems is examined by a lot of researchers. In particular, the objects of these explorations are prospects of the implementation of blended learning in higher education [209]; use of intelligent systems in education [40; 66; 178]; principles of adaptive learning [105]; the use of neural technologies for the individualization of learning [293] and others.

Review of research on the combined use of augmented and virtual reality technologies with adaptive learning systems lets us to notice some works devoted to the current state and new opportunities of adaptive learning in virtual reality [321]; improving massive open online course through augmented reality, adaptive learning and gamification [52]; design implications for adaptive augmented reality based on interactive learning environment for improved concept comprehension in engineering paradigms [228].

However, combined capabilities of augmented and virtual reality technologies with adaptive learning systems has not been thoroughly considered.

New orientations and values of modern education necessitate the understanding student as an unique individual with his/her own individual learning needs. Therefore, educational content presented to students should be adapted to their personal skills and needs, as well as

be interactive and dynamic. However, in recent years, distance e-courses are aimed at the simultaneous learning of a large number of students. Therefore, significant heterogeneity of students' educational outcomes is noticed. This fact necessitates research in the field of individualized learning and improving of distance education.

We will focus on improving e-learning through the combining capabilities of augmented and virtual reality technologies and adaptive learning systems. These means have recently been adopted in various learning models and have shown a significant impact on students' learning experiences.

For our study, we chose AR and VR technologies because according with up-to-date research they make educational content more interactive, individualized, and motivating. Augmented and virtual reality technologies provide interaction with real and virtual objects. Such content visualization keeps students active during the learning, as it increases their ability to understand and process information, as well as adds elements of gamification to learning environment. This is a prerequisite for internal motivation of students to study the material and do tasks, and for getting success.

Adaptive learning systems provide a wide range of tools for individualized training. Therefore, it necessitates development of measures to make learning experience of all participants more successful and to meet the diverse educational needs of students.

Using the combined capabilities of adaptive learning systems and augmented and virtual reality technologies, in our opinion, will provide the best results, because taking into account individual psychological and cognitive characteristics of students affects on their awareness and understanding of educational material. Flexible settings of testing tools provided in adaptive learning systems make possible to identify the psychological characteristics of the cognitive structure of personality for the best selection of educational content at the initial stage.

According to the Fleming's VARKH model the learning process is based on student interaction with educational content [78]. It offers to classify students by main channel of perception of educational information:

- visuals (visual learners): perceive the main part of the educational material with the help of sight; to remember or analyze information more easily, they need to see it in front of them;

- aural learners: the main means of information transfer for them are sounds; for better memorization and assimilation, such students need to voice the educational material or listen to it on a recording;

- digital (read-write learners): prefer educational information presented in the form of words, text; for better perception of information, they need to read or write it down;

- kinesthetic learners: perceive educational material according to the perceptual principle, applying the acquired experience in practice.

Each category corresponds to the preferred method of obtaining and processing educational material, therefore, it is necessary to form individualized educational material, taking into account the predominant channel of receiving information, understanding the dominant type of thinking of students. Conservative methods of content delivery (fixed video, audio, scripts) are not personalized and interactive, so advanced teaching methods are to be implemented to provide a more interesting experience for students. Based on the classification above, it can be considered that students who have visual or kinesthetic channel of obtaining information will best experience the educational material organized with the technology of augmented and virtual reality. So, it is desirable to deliver them educational content by simulators using AR and VR technologies.

In order to develop an adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended learning, in which the capabilities of adaptive learning systems are expanded due to the use of augmented and virtual reality technologies, it is advisable to turn to pedagogical modeling. Taking into account the features described above, we developed a functional learning model using the combined capabilities of augmented and virtual reality technologies based on adaptive learning systems, which is graphically presented in Fig. 2.10.

The model consists of the following main components: a student (education seeker), a teacher (teacher), a database of educational materials,

a database of test tasks, profiles of disciplines, a student model, adapted courses.

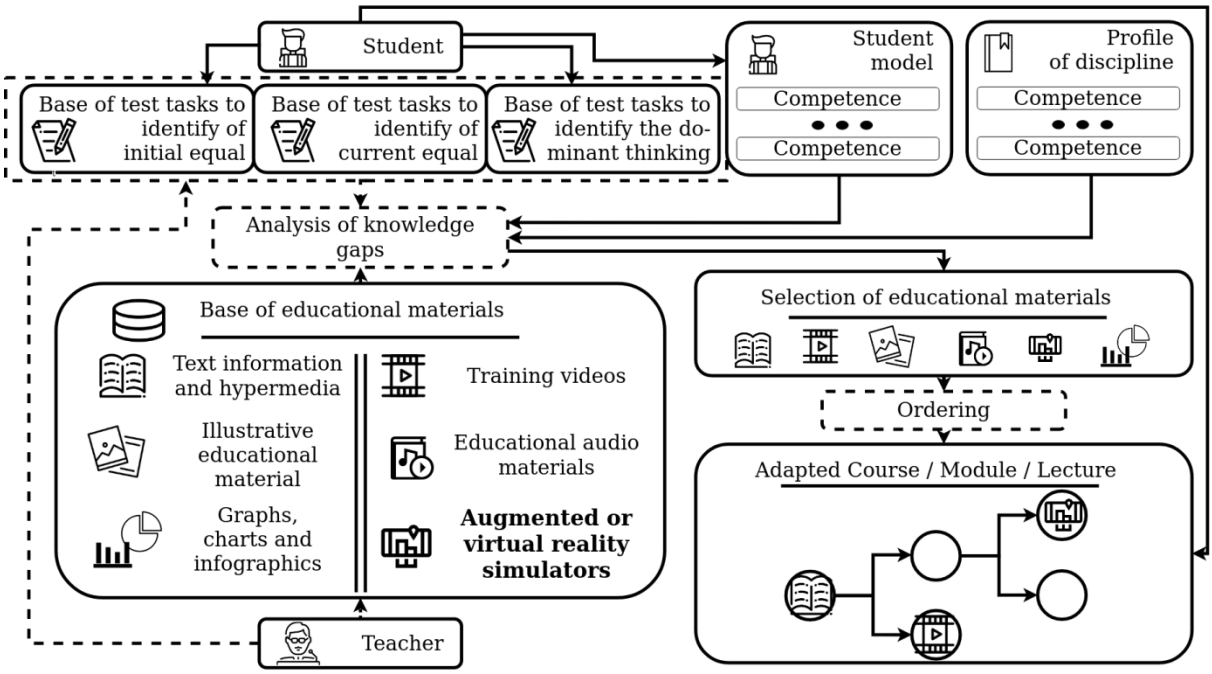

Fig. 2.10. A functional learning model using the combined capabilities of augmented and virtual reality technologies based on adaptive learning systems

The main components of the model are the teacher and the student. A teacher or a team of teachers creates a database of educational materials (text, hypermedia, video and audio materials, illustrations, numerical data visualized in the form of graphs and diagrams, simulators with augmented or virtual reality), a database of test tasks for evaluating educational results and the dominant type of thinking of students, as well as profiles of academic disciplines. Educational materials and test tasks form a methodical component of the education system.

The functioning of the system is based on student-centered and competency-based approaches, therefore, the model includes profiles of disciplines and a student model, which contain lists of competencies that must be developed in students of education. The student model is a benchmark that determines the degree of compliance of the educational results of each individual student with regulatory requirements.

According to the developed model, the organization of training using the combined capabilities of augmented and virtual reality technologies on the basis of adaptive training systems should take place as follows:

1) The team of developers, which includes specialists in the fields of pedagogy, psychology, design, programming, etc., creates a database of educational materials, a database of test tasks, profiles of disciplines, a reference model of a student, and also determines the principles and methods of selecting and arranging educational materials for an adapted course.

2) The student undergoes initial testing to determine his academic achievements and dominant type of thinking. Based on the received data, a model of a specific student is built as a refined instance of the reference model.

3) On the basis of the created model of a specific student and the profiles of the disciplines, the selection of educational materials, their arrangement and the creation of a course adapted to the individual characteristics of the student take place.

4) In the process of training, systematic testing is carried out to clarify its current state. The obtained data is compared with the reference model, and on this basis the model of a specific student is adjusted, as well as the content of the adapted course.

Therefore, the analysis of scientific works devoted to the current state and new possibilities of adaptive learning in virtual reality, improvement of mass open online courses using augmented reality, adaptive learning and gamification, etc. showed that the problems of combining augmented and virtual reality technologies with adaptive learning systems have not received thorough scientific consideration. However, modern views of the student of higher education as a unique individual with individual educational needs require that the educational content be appropriately adapted to his personal needs, skills and preferences. Solving this task is possible due to the combination of adaptive learning systems with augmented and virtual reality technologies, which is based on taking into account the specified individual characteristics. Taking this into account, a functional model of learning was developed using the combined capabilities of augmented and virtual reality technologies based on adaptive learning systems and its

graphic presentation. The model consists of the following main components: a student (education seeker), a teacher (teacher), a database of educational materials, a database of test tasks, profiles of disciplines, a student model, adapted courses. Further research work is aimed at organizing the educational process in higher education institutions based on the developed model.

CHAPTER 3.
INDIVIDUALIZATION AND PERSONALIZATION OF PROFESSIONAL TRAINING IN INSTITUTIONS OF HIGHER EDUCATION ON THE BASIS OF INTENSIFICATION AND A STYLISH APPROACH

3.1. Intensification of professional training of future specialists as a pedagogical problem

The urgent task of today is to ensure high-quality professional training of future specialists in institutions of higher education. To solve it in the theory and practice of professional education, various approaches, methods, and tools are proposed.

Currently, there are two ways of developing professional education. The extensive path is based on increasing the general period of training of specialists, the time for studying individual educational disciplines, and the amount of educational material. Intensive involves the use of pedagogical technologies aimed at increasing the motivational, operational, and cognitive resources of an individual, developing the ability to navigate information flows, constantly updating one's professional knowledge [32, p. 30; 71, p. 170].

The question of the intensification of the educational process in higher education is raised by domestic researchers (L. Bilousova and N. Zhityenova [29], N. Bolyubash [32], N. Burdeyna [44], V. Bukhanevich [42], T. Zhizhko [326], M. Kademiya and L. Didukh [116], L. Koltok [135], Y. Krasylynyk [142], A. Prykhodko [232], O. Pshenichna [233], A. Rybachuk [242], N. Romanyshina [241], O. Sydorchuk [281], H. Yatsenko [324], etc.) and foreign (T. Batova [18], S. Bezborodova and L. Kotlyar [28], O. Husevska [106], O. Yefremova [71], T. Kameneva [120], J. Kuchera and D. Tsimmaro [147], K. Plakhova, O. Kharapudko and R. Nurmieva [216], B. Teytum [288], etc.) scientists.

We recognize the importance of intensification of the educational process, relying in particular on the views of L. Bilousova and N. Zhit'enova,

who emphasize its importance for achieving high-quality results under conditions of increasing information load on a person [29, p. 40].

According to O. Yefremova, the need to intensify the educational process in educational institutions is caused by the following factors:

- the status of intensification in the "polyparadigmatic" and "multicultural" educational space;
- orientation towards the paradigm of fundamentalization of education, which involves the formation of a holistic picture of the world, system knowledge and thinking, a system approach to solving complex interdisciplinary problems in students;
- inconsistency of the results of educational work of pedagogical teams of educational institutions with the efforts made;
- increasing requirements for all components of personality training in educational institutions in order to achieve its competitiveness "on the market of life" [71, p. 169].

Let's consider the essence of intensification as a process, as well as the views of scientists on the intensification of learning.

According to the explanatory dictionary of the Ukrainian language, intensification is an action with the meaning of intensifying, i.e. "to make more intense, productive, effective" [94, p. 500]. The concept of "optimization" is also related to the concept of intensification, which consists in giving something the optimal, most favorable properties [94, p. 851]. The dictionary of pedagogy provides a definition of the concept of "intensification of control", which emphasizes such an important feature of it as improving control without increasing the size of the control apparatus [130, p. 105].

In the psychological and pedagogical dictionary [172, p. 170] the emphasis is placed on the fact that the intensification of the educational process involves increasing its efficiency using the achievements of modern science by improving the forms, methods and means of pedagogical activity, as well as stressing the mental capabilities of the individual [172, p. 170].

Modern scientists in research on the problems of intensification of the educational process rely on the works of Yu. Babansky, devoted to the optimization of education. He interpreted the optimization of education in a secondary school as a purposeful approach to the construction

of the educational process, when the principles of education, the peculiarities of the content of a certain topic, the arsenal of forms and methods of education, the peculiarities of a specific class, its real educational opportunities are considered in unity, and based on a systematic analysis of these data, consciously and the best variant of building the learning process for specific conditions is chosen on a scientific basis [13, p. 53]. As such an organization of the educational process, which ensures the achievement of the maximum possible under the given conditions, the effectiveness of solving educational tasks without exceeding the time allocated for class and homework of students and teachers [13, p. 185].

Criteria for the optimality of the learning process according to Yu. Babanskyi: 1) efficiency, that is, maximum achievement of learning, education and development goals; 2) quality, i.e. compliance of learning results with modern requirements of school education, as well as the maximum capabilities of each student at this stage of his age development; 3) the optimality of teachers' and students' expenditure of time and effort, which is manifested due to their compliance with standards [13, p. 55].

The scientist singled out the following main criteria for the optimization of education: achievement of educational and educational results corresponding to the level of maximum capabilities of each student; expenditure of time and effort of teachers and schoolchildren [13, p. 185].

Depending on the selected criteria and approaches, Yu. Babansky singled out the following levels of training optimization:

a) according to the goals and expected results: I) to increase the efficiency and quality of one separate component of the learning process, for example, to prevent failure or improve work with individual students; II) to simultaneously improve the efficiency and quality of solving several learning tasks; III) for the comprehensive solution of the tasks of training, upbringing and development, set in the educational process;

b) by the nature and number of optimization criteria: I) the effectiveness of the process without taking into account the costs of time, effort and means to achieve this result; II) effectiveness of the process and expenditure of means to achieve goals; III) effectiveness of the process, time and

resources consumption; IV) effectiveness of the process, expenditure of time, resources and efforts;

c) by entities involved in solving optimization tasks: I) school administration and individual teachers; II) school administration and the entire teaching staff; III) school administration, teaching staff, student activity, self-governing bodies, etc.; IV) school administration, teaching and student teams, parents [13, p. 55-56].

The levels of training optimization determined by Yu. Babanskyi are shown in Fig. 3.1.

Content-target or performance levels

- I) increasing the efficiency and quality of individual components of the learning process
- II) simultaneously increasing the efficiency and quality of solving several learning tasks
- III) for the comprehensive solution of training, education and development tasks

Criterion levels

- I) only the effectiveness of the learning process is taken into account
- II) efficiency and cost of funds are taken into account
- III) effectiveness, time and resources are taken into account
- IV) the effectiveness of the process, the expenditure of time, means and efforts are taken into account

Entities involved in solving optimization tasks:

- I) administration and individual teachers;
- II) the administration and the entire teaching staff;
- III) administration, teaching staff, student activity, self-governing bodies;
- IV) administration, teaching and student teams, parents

Fig. 3.1. Levels of optimization of the learning process according to Yu. Babanskyi

Based on the generalization of the characteristics of higher levels of learning optimization, the scientist characterized a global approach to optimization, which involves:

a) comprehensive improvement of the efficiency and quality of the learning process;

b) achieving the optimal state of learning with the minimum required expenditure of time, means and efforts of the participants in the learning process;

c) all participants of the educational process are involved in solving the tasks of training optimization [13, p. 56].

Important thoughts regarding the intensification of training are expressed in the work of V. Bukhanevich [42]. We agree with the researcher that the terms "intensification", "optimization" and "activation" are not always used appropriately in scientific and pedagogical publications. She emphasizes that the main feature of intensification is the reduction of time spent in the educational process. In contrast, optimization involves achieving the optimal time consumption to achieve the set goal, and activation – creating conditions for stressing cognitive activity. In her opinion, intensification can be carried out either by reducing the period of study with an unchanged amount and quality of knowledge assimilation, or by increasing the information that is learned in the same period of time [42, p. 233-234].

In view of the above, V. Bukhanevich interprets the intensification of training "as methodological, technological and psychological improvement of training, which increases informativeness, efficiency and accelerates the educational and cognitive process" [42, p. 234-235]. Under such conditions, "optimization and activation are necessary conditions for intensification of training" [42, p. 235].

L. Bilousova and N. Zhit'enov, based on the analysis of psychological and pedagogical studies, note that despite the diversity of approaches to the interpretation of the intensification of learning, the emphasis is on the fact that it is necessary to ensure the effective, high-quality assimilation of large volumes of material by students in the standard terms stipulated by regulatory documents [29, p. 40]. They emphasize that the intensification of training "presupposes not an increase in the expenditure of effort of the subjects of the educational process or an increase in the mental load on them, not an extension of the training period, but raising to a higher level the productivity of the subject-professional activity of the teacher and the educational-cognitive activity of pupils or students, which should be achieved by improving methods, techniques, means, and organizational forms of education" [29, p. 40].

The author's definition of the intensification of the education of students of economic specialties, which is consistent with the above, is given

by A. Ryzhkova, namely: "the principle of education in modern didactics of a higher school, which requires, under the conditions of an increase in the amount of educational information, to ensure the quality of the training of future specialists while accelerating and reducing the time for mastering the material through the introduction and rational use of effective means, technologies, forms, methods, techniques, and learning conditions" [243, p. 9].

S. Bezborodova and L. Kotlyar note that the intensification of professional training of specialists for its correct understanding and justified implementation in educational institutions must be considered taking into account various scientific approaches [28].

The pedagogical approach involves considering the intensification of learning from the standpoint of: a) didactic and educational principles; b) stages of technology (modeling, diagnosis, design, organization, stimulation, control, evaluation, etc.); c) definition of the content, forms and methods of education. According to the psychophysiological approach, in the process of intensification of training, it is necessary to study and take into account the potential educational opportunities of students, the limits of managing their condition, and the possibilities of using potential mental activity. The acmeological approach focuses on creating optimal conditions for the comprehensive disclosure of the possibilities of education seekers. The cybernetic approach is useful for the analysis and generalization of the results obtained during the automation of individual stages of training, with the aim of managing the psychophysiological state of students in the process of professional training [28, p. 353].

P. Osypov names the leading principles of the intensification of the educational process, in particular: professional orientation; the presence of a professional environment; involvement and participation in future professional activities; relationship between general and professional education; economic validity; increasing the role of self-study of education seekers and their responsibility for results; availability of content, gradual increase in the complexity of tasks; correspondence between the educational load and the individual abilities of the students; the health of participants in the educational process (students and teachers) [204, p. 1].

This agrees with the opinions expressed by Y. Krasylnyk [142]. The scientist summarizes that the intensification of the professional training of future teachers under the master's educational programs at the Higher Education Institution is realized through: rational organization of training classes, when training time is productively used to achieve the set goals; motivated communicative activity of students of higher education in an emotionally colored educational atmosphere; various techniques and forms of work taking into account the individual characteristics of students; a methodically expedient combination of learning tools that allow you to get the maximum effect; introduction of intensive educational technologies in all cases when they provide not only intensification, but also individualization of learning [142, p. 58].

The factors of intensification of training are given in the works of N. Bolyubash [32, p. 30] and L. Koltok [135, p. 278] (Fig. 3.2).

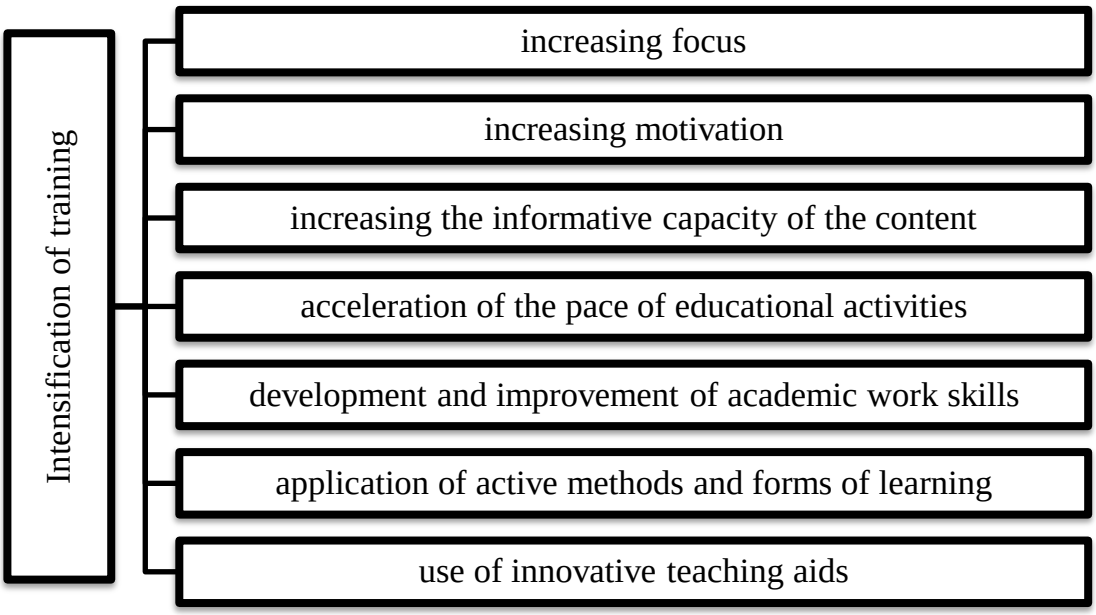

Fig. 3.2. Factors of training intensification (given according to [32; 135])

The teacher, researching the problem of intensification of the thinking activity of students of higher education, singles out the following directions of intensification and optimization of the educational process: strengthening of cognitive motivation of students of education; increasing the informative capacity of the training content; use of active didactic methods and forms; scientifically based management of the process of knowledge acquisition;

development of thinking skills and abilities using mnemonic techniques, visualization, self-control and self-efficacy [110, p. 186-187].

Under the conditions of the intensification of the educational process, the goal of training and the partial goals of its individual stages must meet the following basic requirements: sufficient intensity, orientation to the maximum potential of higher education seekers; basic reach; clarity, which enables students to understand them; specificity; taking into account the educational opportunities of individual applicants and the student body; plasticity, changeability taking into account specific conditions [135, p. 279].

Methods of improving the content of education to increase its informative capacity are defined in works [28; 135]. We will list the most significant for achieving the goals of our research: increasing the informative capacity of educational disciplines by maximally saturating the content while maintaining its accessibility; presentation of material in condensed blocks, strengthening the role of generalization; strengthening of visual connections; improving the selection of educational tasks, exercises and situations; application of algorithmic instructions; use of ICT tools; strengthening of intersubject connections.

In scientific sources, based on the analysis of the results of experimental research and pedagogical experience, various methods and means of intensification of learning in institutions of higher education are proposed. In particular, P. Osipov names the following: application of innovative educational technologies; informatization and computerization of education; use of symbolic and functional schemes, mnemonic symbols that are a support for thinking; Distance Learning; integration of related academic disciplines; joint research work of teachers and students; organization of educational work at all institutional levels (university, department, academic group, individual); identification and consideration of factors that complicate the social and professional development of a higher education applicant [204, p. 1-2].

The experience of intensification of training of students of higher education in the methodology of teaching Ukrainian literature is highlighted in the work of N. Romanyshina [241]. The researcher emphasizes the importance of a well-founded selection of forms and methods of teaching, which makes it possible to maximally involve students

in the educational process, ensure their cognitive activity, and therefore increase the productivity of learning without increasing the workload. Taking into account the specifics of the professional training of future teachers in the methodology of Ukrainian literature, she suggests using role interaction, trainings, coaching, round tables, etc. to solve the tasks of intensification.

A. Rybachuk focuses on the use of interactive learning methods to intensify the educational process, in particular, game forms of learning and the project method [242].

Therefore, scientists include: visualization technologies [110; 29]; e-learning technologies and creating an information environment [32; 120]; technologies of interactive learning [216; 116; 242; 241] etc.

These and other methods can be used at various stages of training intensification. For example, A. Prykhodko proposes a technology for intensification of professional and language training of students from other countries who study in institutions of the higher world of Ukraine with a technical profile, using reference schemes and iconic models [232]. This technology involves the following main types of work: familiarization with the educational material, creation of reference notes, repetition, generalization and systematization of the material. The leading role belongs to various types of repetition, taking into account the specifics of the contingent of higher education applicants.

The process of intensification of training according to A. Prykhodko consists of the following main stages:

1) Study of theoretical material in classroom classes (explanations using various types of visualization, independent preparation of notes by students, consolidation of material based on created notes).

2) Independent work of students in extracurricular time.

3) The first frontal control of assimilation of educational material using methods of reproducing the synopsis, written control, surveys, etc.

4) Oral reproduction of the reference synopsis in order to create conditions for the speech activity of students of higher education.

5) The second frontal control, systematization and generalization of knowledge [232, p. 169-170].

The approaches, factors, and principles considered above characterize the approach to solving the problem of intensification of professional training, when, under the condition of preserving the term of training, its information saturation and productivity increase. However, there is another approach that focuses on reducing the learning period, which is why it is often called accelerated learning.

As B. Tatum notes, accelerated education means any attempt to speed up or shorten the educational process outside of the semester or quarter systems traditional for higher education institutions. Sometimes this means simply reducing the length of the course without changing the number of classroom hours. In other cases, accelerated learning means reducing not only the total duration, but also the amount of classroom work. This organization of the educational process is called intensive, compressed, concentrated or short-term training. At the same time, we may be talking about reducing the time for studying both individual courses and educational programs in general [288, p. 34].

The advantages of accelerated courses and educational programs include: financial savings for students due to the reduction of the study period and the possibility of entering the labor market a year earlier; better learning outcomes (satisfaction, grades, skill development, employment rate and career development); the ability to stand out among other job seekers due to the presence of such abilities as managing one's own activities, working in difficult, stressful conditions [218, p. 8].

The experience of organizing and conducting similar intensive online courses intended for people with limited access to classroom classes (for example, living in remote settlements or working full-time) at the University of Arizona (USA) was characterized by T. Batova [18].

Based on the review of literary sources, the researcher makes the following main conclusions: the format of intensive courses is becoming increasingly popular and has both logistical and pedagogical advantages for students and teachers; intensive courses allow students to focus on the subject more intensively, help them to be more productive and motivated; students are less likely to drop out of such classes and generally get better grades. However, the intensive format has a number of disadvantages, including stressful loads and fatigue for both students and

teachers, insufficient time for reflection, shortened content and its rather superficial study [18, p. 2].

The analytical material [218] provides an overview of the experience of implementing accelerated educational degrees. It is noted that such degrees are one form of flexibility in the educational process, so they are often based on modular or blended learning. The working definition of accelerated degrees proposed by the authors includes the following elements:

- have a structure that differs from traditional degrees;
- provide the same number of credits as a three-year degree;
- offer the same number of study weeks as a three-year degree, but are designed to be completed in a shorter period by using summer vacation time;
- they effectively reduce full-time education to two years, and part-time education to four years [218, p. 6].

Accelerated degrees face some criticism from the academic community, which, combined with negative perceptions and stakeholder concerns, limits their adoption and uptake. Summarizing the critical remarks, the researchers identify the following main problems:

1) It is widely believed that accelerated degrees have lower overall quality and educational outcomes due to low quality teaching and learning, as well as a rather loose interpretation of education quality standards.

2) Obstacles for educational institutions. The development of this form of education is limited by perceptions that such educational programs are more expensive to develop and implement, as they do not adapt well to the existing funding system, which is based on a three-year full-time model; staff concern due to increased workload, lack of time to prepare for classes and other activities, as well as possible reductions; the need for adaptation to institutional processes; insufficient demand from interested parties.

3) Barriers to pursuing accelerated degrees that are often mentioned by educational staff, other stakeholders, and commentators, but not by students themselves, are: lack of awareness of flexible learning options combined with a strong culture of a three-year full-time bachelor's degree; limited educational experience of students; the perception that this learning option requires a large workload with less time to comprehend the material

and leads to lower results; higher living costs per year, together with fewer opportunities to combine paid work with study.

4) Problems of employers. It is believed that employers may generally not have information about accelerated degrees or consider such qualifications as less valuable and qualitative when hiring, which theoretically limits the opportunities for professional realization of graduates of such educational programs [218, p. 6-7].

However, as the authors of the study emphasize [218], there are practical evidences in favor of the fact that these obstacles can be successfully overcome.

The experience of organizing accelerated professional training of accounting specialists is described in the work [70]. Accelerated programs offer the same content, forms, and methods of instruction and assessment as traditional programs. The authors of the study showed that there were no significant differences between graduates of traditional and accelerated programs in terms of the success rate of passing the certification exam [70, p. 10].

The analysis of scientific developments and the experience of foreign specialists made it possible to note that the introduction of differentiated education is an actual method of intensification of the educational process. As noted by T. Santangelo and K. Tomlinson, the main goal of differentiated education can be considered the task of maximizing the educational potential of each individual student, taking into account his educational experience. They emphasize the need to focus teachers' attention on three important characteristics of education seekers: willingness to learn; interest in the educational process; direct psychological profile [248]. However, we note that although the research contains interesting results, it focuses on taking into account the experience of teaching in groups of students who have already studied with certain teachers before, as well as on the mental capabilities of students without taking into account their personal characteristics. In our opinion, this somewhat limits the significance of the presented results.

The research of A. Margaryan, M. Bianko and A. Littlejohn, who emphasized the need to take into account the needs of each student in the educational process, can be considered more detailed. However,

the authors did not reveal the specifics of the implementation of this approach, which encourages further research [164]. The work [148] was identified as important for further research, the authors of which investigated the psychological characteristics of students and established that differentiated learning is associated with a complex set of variables, such as: the student's own effectiveness; belief in the accuracy of the educational material; teaching experience of pedagogical workers, their professional development and its certification.

Therefore, the intensification of the educational process is aimed at achieving a high level of quality and effectiveness of education, in particular, professional training of future specialists of various profiles in higher education institutions. And therein lies its undeniable significance. However, sharing the opinion of L. Bilousova and N. Zhityenova, we emphasize that the implementation of the measures necessary for this requires quite intense preliminary training from pedagogical and scientific-pedagogical workers [29, p. 46].

A characteristic feature of the professional training of future software engineers in institutions of higher education is the increase in the amount of educational information, updating the content while preserving the importance of the fundamental foundations of computer science, which is caused in particular by the development of information and communication technologies. As emphasized by scientists (I. Bardus [16], I. Krasheninnik [141], S. Konyukhov [138], A. Stryuk [273; 274], V. Koncedailo [137], T. Vakalyuk [308], V. Kruglyk [144], O. Naumuk [183], etc.), nowadays the requirements for the level of professional training of software engineers are increasing on the part of society and employers. In their entirety, these factors determine the need for measures to improve the quality of educational programs by reviewing their content to ensure its compliance with the current state of the IT industry, the use of optimal forms, methods and means of education, adequate to the needs and capabilities of students of higher education, intensification of the educational process, etc.

Professional training of future IT specialists, in particular software engineers, in institutions of higher education under bachelor's and master's educational programs is in the focus of many domestic and foreign

researchers. Its theoretical and methodological foundations are substantiated in the works of I. Bardus [16], T. Vakalyuk [308], O. Glazunova [86], V. Kruglik [144], Z. Seydametova [253], S. Semerikova [250]. Its separate aspects, in particular the forms, methods and means of training and formation of professional competences of future software engineers, were studied by L. Balan [14], M. Vinnyk [311], T. Voloshina [315], L. Zubyk [327], V Kolisnyk [134], V. Koncedailo [137], S. Konyukhov [138], I. Krasheninnik [141], O. Naumuk [183], V. Sedov [249], A. Stryuk [274], S. Symonenko [282], A. Chorna [56], D. Shchedrolosiev [257] and other scientists. It is worth noting that they substantiated a number of pedagogical and organizational conditions, the implementation of which contributes to the intensification of the educational process. However, comprehensive issues of intensification of professional training of future software engineers in institutions of higher education are practically not covered in scientific research.

The above allows us to project the factors of the need for intensification of the educational process, given above, for the professional training of future software engineers in institutions of higher education, namely:

1) fundamentalization of informatics education is important [217], since there is a significant risk of paying attention only to applied aspects of computer science or software engineering;

2) the organization and implementation of the educational process, the creation of a favorable environment for achieving the expected level of educational quality and professional qualification of graduates require significant resources, but the effectiveness of their use is limited by many factors, in particular, the level of preliminary training of entrants, their readiness and ability to study, etc.;

3) the growth of qualification requirements for software engineers, in particular for the formation of "soft" skills in them, leads to the need to strengthen their professional training.

Therefore, it can be stated that the intensification of the educational process, taking into account the trends in the development of the IT industry, the achievements of pedagogical science, and the personal qualities of the students of higher education, is a relevant direction for improving

the professional training of future software engineers in institutions of higher education.

Now there is a need to reduce the terms of professional training of future software engineers in institutions of higher education for the bachelor's degree from four years, which is the standard period of study, to two to three years with further transition to self-improvement of qualifications under the conditions of industrial activity by profession at enterprises based on the principle of lifelong learning. The use of traditional approaches to education does not allow providing full-fledged practical training during such a shortened period of education [198].

This correlates with our thesis about the need to move away from traditional teaching methods and intensify the professional training of future software engineers, taking into account the current data of psychological and pedagogical research, as well as the individual characteristics and educational interests of students of higher education. It should be expected that the result of the relevant measures will be a reduction in the time it takes for future software engineers to develop basic knowledge, understanding and abilities, as well as the creation of opportunities for their in-depth and / or specialized professional training in educational programs at the bachelor's and master's levels.

Examining in more detail the problems of intensification of the educational process in specialties of the field of knowledge 12 Information technologies in institutions of higher education, we can note that the growth of their relevance is directly related to the increase in demand for information and digital products and, accordingly, the modern trends of the industry to "dominate" the labor market both in Ukraine and in the world in general. In our opinion, the root cause of this trend is the development and implementation of high-quality software by domestic specialists. This strengthens Ukraine's position among countries participating in international grant and private projects, which positively affects the level of the state's interest in the development of the industry and the level of its economic development in general. The growing popularity of Ukrainian software development creates conditions for expanding the labor market's need for highly qualified IT specialists, including software engineers who are graduates of bachelor's and master's educational programs. This makes

it necessary to speed up the pace of professional training in institutions of higher education. The most effective way to solve this problem is the intensification of training.

In addition to the problem of insufficient amount of time for training students of higher education in the field of knowledge 12 Information technologies, additional tasks arise related to the need of employers for IT specialists who not only possess professional knowledge and are able to independently solve educational and production tasks, but also and at a high level speak a foreign language, have developed leadership and management qualities, self-development skills, etc. This determines the relevance of the study of various aspects of the intensification of the educational process, the development of new approaches to solving the problem of intensification of the professional training of future software engineers in the educational programs of the bachelor's and master's levels in the specialties of the field of knowledge 12 Information technologies, in particular within the limits of professional disciplines.

We can note that there are contradictory trends in the modern labor market for IT specialists and in particular software engineers: on the one hand, there is a high demand for specialists of various levels, from beginners to software project managers; on the other hand, there is a high level of competition among IT workers. We made this conclusion based on the study of analytical materials and scientific publications [238; 69; 74; 109; 152; 198; 202; 245; 258]. However, the analysis of these trends proves that they are interrelated, since the most acute is the need for specialists of medium and high qualifications who determine trends and direct the development of the industry.

In connection with this, the present is characterized by a significant increase in the requirements for the professional training of software engineers during their higher education. At the state and regional levels, there is talk of the need to intensify the training of future software engineers in institutions of higher education in order to quickly fill the labor market with specialists. In particular, in the "Study on the sectoral strategy for the development of information and communication technologies 2019-2023", carried out by the Ministry of Economic Development and Trade of Ukraine, it is stated that among other important factors

of the development of the domestic IT industry, the early formation of practical skills in future IT specialists and creation of opportunities for mastering modern IT technologies in the process of learning in institutions of higher education [74, p. 7]. In this regard, the strategic goal is to increase the supply of specialists whose qualification level will meet the requirements and needs of the IT industry. Among the ways of its achievement, the establishment of cooperation between the higher education system and the information technology industry at both the state (between the Ministry of Education and Science and the IT industry) and regional (between universities and local IT clusters, companies, associations) levels is highlighted in order to improve the quality of the relevant bachelor's and master's educational programs, as well as improving skills in improving the qualifications of scientific and pedagogical workers [74, p. 8].

The fact that the teaching of professional disciplines for future software engineers in institutions of higher education is based on the content of their professional activities (availability of educational projects, the possibility of creative development, modeling of professional processes, creation of conditions for full deepening, simulation of real production processes, etc.) is an absolute fact, which in turn, it allows you to create a virtual professional environment by simulating problematic and production situations.

To determine the possibilities of intensifying the professional training of future software engineers in institutions of higher education, we analyzed the works [145; 146; 198], in which some priority requirements for the qualification of software engineers – graduates of higher education institutions are given, namely: skills in creating and debugging software; computer equipment design and support skills; ability to maintain information; the ability to identify vulnerabilities in developed software; ability to develop and maintain web resources for the Internet; skills in setting up the protection of internal systems of companies, etc.

The process of training future software engineers is not fully standardized, its effectiveness is related to the individual psychological characteristics and peculiarities of the cognitive processes of each individual student. Considering this, with the aim of intensifying professional training in educational programs of the first (bachelor's) and second (master's) levels

in specialties of the field of knowledge 12 Information technologies, active research work is currently being conducted to solve the problems of activating the intellectual activity of the individual, as well as finding ways to intensify learning by achieving the maximum efficiency of the use of cognitive resources of future specialists.

Within the framework of the study, it is appropriate to pay attention to the work of V. Osadchyi and K. Osadcha, in which the scientists identified modern trends in the informatization of education, in particular: the introduction and distribution of electronic learning, services and tools for teachers, students, managers and parents in order to organize the cooperation of all the specified participants in the educational process, development of cloud technologies [199]. The authors emphasized that these problems are leading in the scientific space. However, before determining the quality of a graduate's professional training, it is necessary to identify the relevant criteria that should be taken into account. Among them are criteria for the quality of the content of education, personnel support (the ability of teachers to use modern information and communication technologies, the availability of scientific degrees and scientific titles, the availability of methodological developments and scientific publications, creative potential, etc.), learning technologies (conducting lectures, laboratory and practical classes, control works and testing), technical support, training results [17, p. 217]. As further noted in the study [200], employers' demands for engineering and technical knowledge and skills are constantly increasing. This is due to the accelerated evolution of technical skills, the emergence of new engineering professions and the penetration of technology into all spheres of human life.

The conducted analysis of scientific research on the optimization and intensification of training, on the problems of professional training of future IT specialists, in particular software engineers, in institutions of higher education, as well as analytical materials that highlight the requirements of the labor market for workers in the field of information technologies, provided grounds for formulating the concept of "*intensification of professional training of future programmer engineers in institutions of higher education*", interpreted by us as a purposeful, systematic and scientifically based approach to the construction of the educational process

according to the educational programs of the first (bachelor's) and second (master's) levels in specialties of the field of knowledge 12 Information technologies, when, in order to achieve the maximum effectiveness of this process in the specific conditions of a higher education institution, the cognitive styles and real learning opportunities of higher education applicants, learning principles, content features, an arsenal of learning forms and methods are considered in unity.

Thus, the intensification of the professional training of future software engineers in institutions of higher education under educational programs of the first (bachelor) and second (master) levels involves a combination of effective teaching, learning and educational content in order to ensure the quality of the educational process and achieve its leading goal – the formation of the personality of a highly qualified a specialist capable of independently solving production tasks in the field of information and communication technologies and developing high-quality software products. Intensification relies on taking into account scientific approaches, laws, principles, as well as individual qualities of all participants in the educational process. Its integral elements are the use of forms, methods and means of education optimal for the given conditions, as well as the activation of the cognitive activity of students of higher education. In view of this, the intensification of training can be considered as one of the effective mechanisms of individualization and personalization of professional training of future specialists in institutions of higher education.

3.2. Implementation of the theory of cognitive styles in psychological and pedagogical research

Modern society is diverse and heterogeneous, has a complex structure and different levels of development not only in the world in general, but also in individual countries. It is characterized by such concepts as: "information society" [69; 213], "knowledge society" [230; 294], "risk society" [24], "sustainable development society" [297; 305]. Analysis of these fundamental concepts is beyond the scope of our study, but it is important that they all recognize the importance of knowledge, information, information and communication technologies and education.

In general, in the information society, any activity makes certain demands on the ways of processing information by a person, so its success depends, in particular, on the cognitive style of the individual [223, p. 310].

In connection with this, an important direction of psychological and pedagogical research today is the study of the individual as a consumer of information, "which is somehow decoded, processed, interpreted and used to achieve the final result of the activity" [162, p. 4].

In the process of formation and development of this ability, based on the provisions of the student-centered approach, personal qualities (temperament, motivation, abilities, etc.), peculiarities of cognitive processes (memory, thinking, attention, etc.) of students of higher education should be taken into account, as well as their inherent ways of handling information. This is consistent with the views of scientists that the quality of professional training depends on individual psychological characteristics and features of human cognitive processes [162; 223].

Such "characteristic models of information processing, including perception, conscious reasoning, memorization, problem solving and understanding of the world in general" are called *cognitive styles* [290, p. 117]. They represent sufficiently stable individual methods of information processing and interaction with the information field [140, p. 179]. Also important is the fact that each person can show different stylistic features depending on the activity situation, that is, he has different cognitive styles [140, p. 181].

Let's briefly consider what is understood by the term "*information field*" in modern scientific discourse. As noted by S. Bukharin and S. Malkov, the information field provides interaction between various objects (people, organizations, enterprises, etc.), which can be conventionally divided into sources of information and addressees. Any object can be both a source and an addressee [43, p. 136]. In the process of interaction of the objects of the information field, each source of information tries to reach the target audience and bring informational influences to it with the necessary frequency. There can be many such sources, they can compete or cooperate with each other, form temporary or permanent coalitions [43, p. 139].

The information field is considered by many sciences taking into account the specifics of the interaction of its objects, in particular its content. A. Bolotnov, investigating the linguistic aspect of this phenomenon, interprets the informational field of the individual as "the space of communication or individual discourse consisting of discursive practices in various spheres of human communication in the course of his professional, creative or personal life. ... The field includes a number of associations related to a person, his thesaurus, a picture of the world, a system of values reflected in the discourse" [31, p. 30].

A. Gubankov, researching the cultural aspect of the information field of network communication, defines it as "the reproduction of the historically developed order of stable relationships between different social groups regarding their collective existence in the natural and cultural conditions of the urban environment, as well as a collection of products, ideas, structures and technologies, which are generated in the process of these relationships and flow from the practices of life activities in accordance with this order" [104, p. 69].

O. Susska notes that the information field of an individual is a continuous phenomenon, in the process of construction of which program and implementation functions are performed. To create his own information field, an individual must determine his motives (psychological, social, sociocultural, etc.), internalize his interests, choose an acceptable type of iconic constructions (television image, computer video, etc.) [279, p. 134].

Therefore, since a person acts as an active creator of his own information field, its content, elements, as well as methods of interaction

between them depend to some extent on the individual qualities of the individual, and are also related to the peculiarities of his activity, in particular educational and professional, which is important for our study.

Taking into account the above, we will formulate a judgment about some features *of the information field of a software engineer*:

1) its objects are everyone with whom the software engineer interacts in one way or another on any issues in the course of professional activity (managers, colleagues, customers, consultants, employees of third-party organizations and enterprises, etc.);

2) its content includes all information that is created and used in the process of this interaction. For the most part, it refers to a certain direction of software engineering, which is related to the professional activity of a software engineer, but it also includes, for example, social information necessary for the organization and maintenance of industrial relations, etc.

The informational field of a future software engineer who obtains a bachelor's or master's degree has certain differences: in its content, the production component is presented to a lesser extent and it is mostly related to the implementation of educational projects or practical training, but theoretical and applied aspects are presented in a more diverse way software engineering and computer science.

The problem of cognitive styles, their study and consideration in the educational and professional activities of specialists of various specialties is sufficiently well presented in domestic and foreign scientific publications, in particular in the field of psychology. From among Ukrainian scientists, various aspects of it are investigated: V. Bazhanyuk [23], O. Belyavska [25], S. Bondar [33; 34], T. Bushueva and A. Averyanova [47], G. Bushchak [46], M. Vintoniv [312], A. Vlasenko [313], N. Hordynia [101], S. Doskach [68], R. Kalamage [117; 118], I. Koval [140], N. Kostruba [139], S. Maksymenko and I. Pasichnyk [162], M. Opachko [192], M. Popova [223; 220; 221; 222], O. Portyana [226], O. Sannikov and S. Zavalenko [247], G. Solomina [263] and others. Among foreign researchers, E. Kuuls and G. Van den Broek [60; 61], M. Yehorova [72], M. Kholodna [124], L. Ausbern and F. Ausbern [11], A. Galiakberova and E. Galyamov [83], D. Kolb and A. Kolb [131; 132], J. Liedtke and L. Fromhage [157], M. Key and S. Armstrong [234], K. Tinajero and M. Paramo [292], G. Witkin and

D. Goodenough [320], M. Zhang, Ks. Wong, F. Wong and H. Liu [325] and others.

Cognitive styles of the individual are studied within the framework of cognitive psychology – the science "of the processes of obtaining, storing, transforming, creating and using knowledge by a person" [57, p. 7], which considers a person as a system that searches for information about objects and events in the surrounding world, processes and stores the received information [6, p. 10].

The methodological basis of the application of the stylistic approach in the educational process is formed by four main theoretical sources: the theory of psychological differentiation by H. Vitkin (Gestalt psychological tradition); the theory of cognitive controls by J. Klein, R. Gardner, F. Holtzman, G. Schlesinger (psychoanalytic tradition); J. Kagan's theory of cognitive pace (study of individual categorization strategies); theory of individual conceptual systems by O. Harvey, D. Hunt, H. Schroder, theory of personal constructs by J. Kelly (cognitive theories of personality) [57, p. 283].

A significant contribution to the development of applied aspects of the theory of cognitive styles was made by M. Popova. In particular, she analyzed and summarized the materials of a number of scientific studies and concluded that a person's cognitive style largely determines a person's choice of profession, as well as his subsequent success in professional activity [220, p. 215]. In addition, for the purposes of our work, her conclusion is important that specialists working in the field of information technologies have a much more knowledgeable style, which involves operating with knowledge, than a creative one, which involves operating with ideas [220, p. 213]. The researcher also showed that certain cognitive styles prevail in different groups of specialists [223, p. 315].

In the work [221], M. Popova analyzed the peculiarities of the manifestation of cognitive styles in the structure of abilities of telephone consultants. For this purpose, an experimental study was organized, in which several groups of operators of the public and private sector, which had different specifics of interaction with clients, took part. During the experiment, psychodiagnostic methods were used to determine the cognitive-activity style, creative abilities, speed and flexibility

of thinking, the style of information acquisition, the structure of temperament and intelligence [221, p. 221]. The obtained results were used to formulate recommendations for personnel selection. The work [222] presents a theoretical model of a person's cognitive style, developed by a researcher with an emphasis on its importance as a factor of professional competence.

According to the definition of M. Kholodnaya, "cognitive styles are individually peculiar ways of processing information about one's environment in the form of individual differences in perception, analysis, structuring, categorization, evaluation of what is happening" [124, p. 38].

According to the definition of M. Opachko: "Cognitive style is a prevailing, dominant way of perceiving and processing information, which reflects the individual properties of a person; it determines the effectiveness of assimilation of the learning content (in other words, the individual projection on the implementation of the learning content)" [192, p. 199]. The researcher notes that the cognitive style can otherwise be called cognitive or educational, and it is associated with the functional asymmetry of the brain [192, p. 199].

The psychological phenomenon of cognitive style has a number of characteristic features, in particular:

- it is an instrumental characteristic of intellectual activity, which can be contrasted with a productive characteristic;
- it characterizes the peculiarities of the organization of the cognitive sphere and is not directly related to the peculiarities of its content;
- cognitive style is a bipolar psychological dimension, that is, it has two poles – extreme forms of intellectual behavior;
- it makes no sense to apply evaluative judgments to cognitive styles, since each pole can contribute to effective individual adaptation depending on the activity situation;
- cognitive style is a stable characteristic of the subject, which is stably manifested in different situations at different levels of intellectual functioning;
- cognitive style is giving preference to a certain way of intellectual behavior (that is, the subject under conditions of freedom of choice chooses the way of perception and analysis of the situation that best corresponds to his psychological capabilities) [124, p. 40].

Cognitive styles characterize two aspects of an individual's intellectual activity:

1) mental representation of situations (creating a mental image): the limits of the mental image of the situation, the degree of their permeability, the articulation of the mental image, the selection of various generalized categorical levels in it, the integration of different modalities of experience in the mental image;

2) the ability to control mental activity and the formation of mechanisms of involuntary intellectual control: control of information processing processes (organization of basic processes of cognitive reflection), control of motor and affective activity (means of restraining impulsive behavior) [57, p. 311].

As noted by I. Koval, cognitive styles coordinate the interaction of the cognitive processes of an individual, reflect individual ways of perceiving and analyzing environmental stimuli, and therefore are the cause of different understanding and evaluation of situations by different people [140, p. 180]. In addition, cognitive styles are associated with individual features of attention [47], perform adaptive functions and can facilitate or complicate a person's adaptation to specific learning or activity conditions [313].

According to M. Popova, they determine the success of an individual in performing various types of activities [220, p. 210], as well as in the process of studying in institutions of higher education, ensuring the orientation of students [223, p. 311; 220, p. 210]. The researcher claims that cognitive style is a dynamic formation that affects the choice of the field of activity and professional success, but is also affected and changes in the process of this activity, that is, it is possible to replace ineffective cognitive styles with effective ones in order to increase the professional competence of an individual [223, p. 319].

The above is correlated with the fact that there are two views on cognitive styles: 1) according to the individual position, the cognitive style is determined by the individual characteristics of the personality; 2) according to the external position, it depends on the specifics of the activity [222, p. 470]. As an individual-typological property, cognitive style reflects the personality's temperament and is an organizing structure

of intellectual abilities. As a regulator of mental activity, it determines the methods of activity (procedural characteristic), as well as its success and efficiency (resultative characteristic) [222, p. 473]. This approach is reflected in the theoretical model developed by M. Popova [222, p. 472].

One of the issues discussed in psychological science is the stability and immutability of cognitive styles. As M. Vintoniv notes, for quite a long time it was believed that cognitive styles practically do not change, but currently researchers have established that a person can "move from one pole to another under the influence of a change in the task" [312, p. 108-109]. It should also be taken into account that the need to adhere to strict rules or a limited choice of methods of activity leads to a significant complication of the formation and manifestation of a person's individual style, in particular cognitive [140, p. 178].

During the period of development of the theory of cognitive styles from the 50s of the 20th century, several approaches to their classification were formed. However, we agree with N. Kostruba, who rightly notes that it is somewhat conditional, since any person has a set of cognitive characteristics that manifest themselves in different combinations depending on environmental conditions [139, p. 74]. This is consistent with the conclusion of J. Liedtke and L. Fromhage that a person can show different cognitive styles in different situations, and sometimes these styles can coexist [157, p. 1].

Cognitive styles are most often distinguished based on their bipolarity. We will give some characteristics of the styles selected according to this feature, based on the information systematized by M. Kholodna:

1) Field dependence / field independence (PZ/PZ). In a narrow sense, it is the ability to single out a simple detail in a complex figure, and in a broad sense, it is an indicator of the level of psychological differentiation [124, p. 52]. Affects the effectiveness of complex types of intellectual activity, for example, working with text: in situations where the text requires reorganization, PNs of individuals show mostly better results than PWs. People are mostly active participants rather than observers in the educational activities of PNS. In addition, internal motivation for learning is of primary importance for them. In situations of communication and interpersonal interaction, personality software is more

socially oriented, which in general relies more on the external environment. They better feel social influences, are more attentive to social sources of information, show better empathy, are prone to collective forms of activity. That is why the external motivation of learning is of leading importance for the personal development of individuals [124, p. 46-55].

2) Narrow / wide range of equivalence. This cognitive style characterizes individual features of orientation to the features of similarities or differences of objects. In the case of a narrow range of equivalence, a person tends to single out many groups that have a small volume; in the case of a wide one, there are few groups with a large volume. So, the essence of style is how many categories exist in the individual conceptual experience of a person [124, p. 60-61].

3) Rigid / flexible cognitive control. Style characterizes the degree of subjective complexity of changing the way information is transformed in situations of cognitive conflict. Individuals with rigid control have difficulties in the transition from verbal to sensory-perceptual functions. In individuals with flexible control, this transition occurs mostly without complications [124, p. 68].

4) Tolerance / intolerance to unrealistic experiences. Style is revealed in situations of uncertainty. Tolerance for unrealistic experiences gives a person the ability to accept experiences that do not correspond to his existing concepts and understanding. Tolerant individuals evaluate objects and situations based on actual characteristics. Intolerant people tend to deny experience that contradicts existing knowledge [124, p. 71].

5) Narrowness / breadth of the category. Style characterizes the degree of subjective differentiation of the content of one category. In the case of a narrow category, the scope of its application is limited, in the case of a broad one, the category unites many objects and / or phenomena [124, p. 65-66].

6) Focusing / scanning control. The style characterizes the individual features of the distribution of attention, which is manifested in the breadth of coverage of various aspects of the situation. Scanning (broad) control is characteristic of individuals who quickly perceive many aspects of a situation, highlighting objective details. Individuals with focusing

(narrow) control show fragmentary attention, highlighting only clear signs of the situation [124, p. 74-75].

7) Smoothing / sharpening. Style characterizes individual features of information storage in memory. The smoothing style is characterized by the simplification of information during its long-term storage in memory. The selection of specific details when storing information in memory is inherent in the sharpening style [124, p. 78].

8) Concrete / abstract conceptualization. Style characterizes individual features of the conceptual sphere of personality. Individuals with a specific conceptualization are characterized by insufficient differentiation and integration of concepts, they are oriented towards authorities, intolerant of uncertainty, prone to stereotyped decisions, situational behavior. Abstract conceptualization involves high differentiation and integration of concepts. Orientation to one's own experience, propensity to risk, independence, creativity, etc. are characteristic of such personalities [124, p. 83].

9) Impulsivity / reflexivity. The style characterizes the individual characteristics of the speed of decision-making in situations of uncertainty, for example, in the case of choosing among many alternatives. Impulsive individuals tend to react quickly without analyzing possible alternatives. Reflective personalities react slowly, relying on a careful analysis of alternatives. The main difference between the poles lies in the volume of information that a person uses to make a decision: impulsive ones operate with insufficient volume, reflexive ones tend to obtain a maximum of information in advance [124, p. 79-83].

10) Cognitive simplicity / complexity. Cognitive complexity means that an individual perceives a situation, highlighting many aspects in it. Cognitive simplicity indicates that the individual interprets the situation in a simplified manner, operating with limited information [11, p. 338; 57, p. 301].

Despite the development in scientific research of the characteristics of bipolar cognitive styles and methods of their diagnosis, as shown in [313, p. 34], now there is a tendency to introduce polypolar constructs, for example: theoretical / practice-oriented / emotional; creative / population / scarce / productive / rigid etc.

There are also other approaches to identifying types of cognitive styles. One of them was proposed by E. Kuuls and G. Van den Broeck based

on the study of the activities of managers and entrepreneurs [60; 61]. In particular, they showed that the activities of managers can involve the performance of certain tasks (orientation on achieving goals) or interaction with other employees (orientation on people) [60, p. 104]. Scientists have distinguished three cognitive styles: knowing (operates with knowledge, facts), planning (operates with structures and plans) and creative (operates with opportunities and ideas), – they have indicated the manifestations of each of them in various types of activities, and also identified their strengths and weaknesses [60, p. 107]. Individual characteristics are given in the Table 3.1.

Table 3.1. Generalized characteristics of cognitive styles according to E. Kuuls and G. Van den Broek [60, p. 107]

Parameter	Cognitive styles		
	Knowing	Planning	Creative
Activities in situations of achievement of goals			
The way of making decisions	Detailed analysis, slow decision-making	Structural analysis, quick decision-making	Intuitive analysis, extremely fast decision-making
Strengths	Analytical abilities, logical thinking	Organizational abilities, compliance with rules	Powerful imagination, non-standard thinking
Weak sides	Creativity	Unforeseen changes	Implementation of generated ideas
Activities in situations of interaction with people			
Conflict resolution style	Based on rational and logical arguments	Rational, diplomatic way, quick decisions	Mostly emotional, assertive, sometimes provocative
Strengths	Reliability	Care	Flexibility
Weak sides	Straightforwardness, lack of empathy	Demanding to oneself and others, excessive control	Difficulty reaching a compromise, impulsiveness

Another approach to the classification of cognitive (learning) styles is based on the theory of empirical (experimental) learning developed by D. Kolb [131; 132; 133]. He proposed a model of the learning cycle, which has two dimensions: 1) gathering experience (obtaining learning

information); 2) transformation of experience (processing of educational information). Two related types of experience accumulation (concrete and abstract), as well as two related types of experience transformation (reflective observation and active experimentation) [132, p. 44].

The process of obtaining and/or constructing new knowledge by the student includes all four types of operations, which depends on specific conditions. An ideal learning cycle (Fig. 3.3) represents a sequence: obtaining specific (personal, sensory) experience, reflective observation, understanding, action [132, p. 44].

Depending on what types of collection and transformation of experience dominate the personality, four cognitive styles are distinguished:

1) divergent: specific experience + reflective observation; qualities: good imagination, ability to generate ideas, ability to analyze information from different perspectives, interest in people, various cultural interests;

2) assimilative: abstract conceptualization + reflective observation; qualities: the ability to create theoretical models, the ability to think inductively, giving preference to working with abstract concepts before interacting with people;

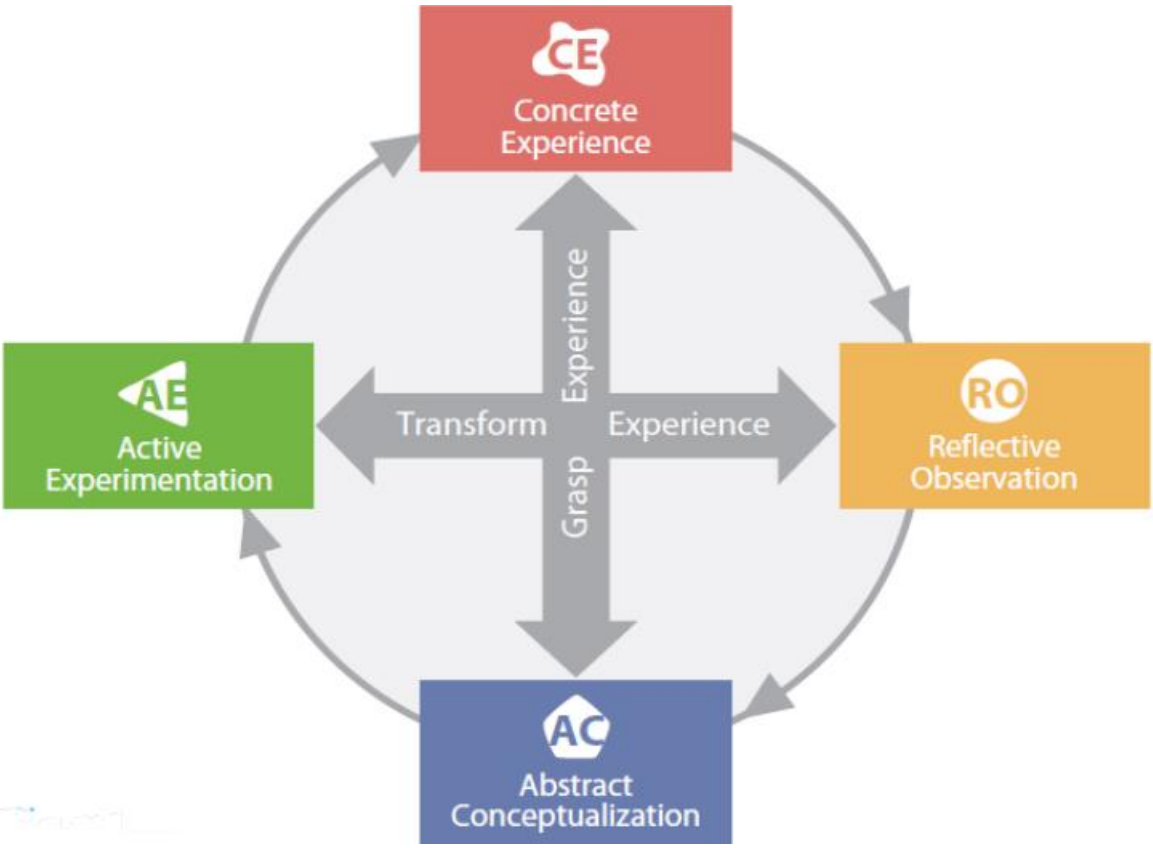

Fig. 3.3. D. Kolb's learning cycle [131, p. 8]

3) convergent: abstract conceptualization + active experimentation; qualities: a person is capable of implementing ideas, can focus on thinking about specific problems, is unemotional, has narrow interests;

4) accommodative: specific experience + active experimentation; qualities: propensity to act, ability and propensity to take risks, good response to circumstances, intuitive problem solving [131, p. 8; 132, p. 44; 133, p. 230; 262].

There is also an improved classification of D. Kolb's cognitive styles, the so-called version 4.0, in which the author and his followers combined the main and intermediate ways of interacting with information in the learning process. This made it possible to describe 9 cognitive styles (Fig. 3.4):

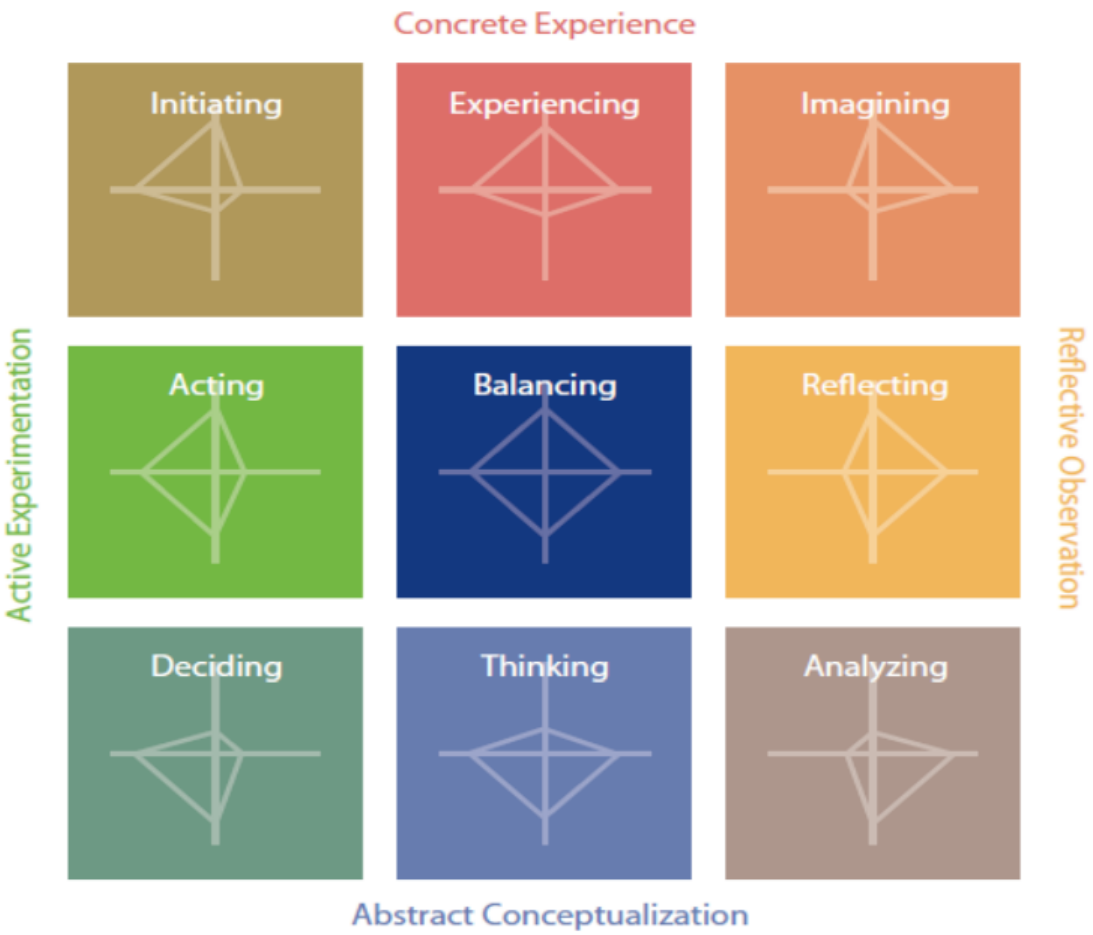

Fig. 3.4. D. Kolb's learning cycle (version 4.0) [131, p. 14]

1) Initiating style: initiating action to gain experience in certain situations. Characterized by the ability to initiate actions to further deal with experiences and situations.

2) Style of personal experience: searching for meaning by "immersing" in experience. Characterized by the ability to find meaning through personal practical and / or sensory experience.

3) Representation style: representation of possibilities through observation and understanding of experiences and acquired experience.

4) Reflection style: combination of experience and ideas through sustained reflection.

5) Analytical style: integrating ideas into concise models and systems. Characterized by the ability to integrate and systematize ideas through reflection.

6) Thinking style: Disciplined engagement in abstract reasoning and logical reasoning. It is characterized by a high degree of development of the ability to abstract and logical thinking.

7) Decision-making style: the use of theories and models to make a decision on solving a certain problem or choosing a course of further action.

8) Acting (acting) style: powerful motivation to carry out purposeful activities that unite people and tasks.

9) Balanced style: ability to adapt to the situation; the ability to assess advantages and disadvantages and prioritize action over reflection, experience over reasoning. It represents a balanced combination of concrete experience, abstract thinking, reflective observation and active experimentation [131, p. 14-15].

M. Opachko proposed a classification of cognitive styles, which combines two features: 1) asymmetry of the cerebral hemispheres (left hemisphere, right hemisphere); 2) modality of displaying information (extroversion, introversion) [192, p. 200].

This approach allowed her to identify four cognitive styles that differ in their main characteristics and manifestations in learning situations:

1) Left-hemisphere extrovert: uses iconic symbols, asks clarifying questions, formulates clear answers, proves an opinion argumentatively and expressively, actively interacts with the environment to clarify the incomprehensible.

2) Left-hemisphere introvert: "internal thinking" prevails, answers are restrained and laconic, analyzes explanations of the teacher and other students to clarify the incomprehensible.

3) Right-hemisphere extrovert: unrestrained behavior, violent emotions in various learning situations, the solution to the problem mostly appears as a lightning insight, assimilation of the learning content is accompanied by inconsistency and emotionality.

4) Right-hemisphere introvert: a thoughtful thinker immersed in the world of images, characterized by slow actions and indecisiveness in responses, the most vulnerable and least adapted to learning in a group of all styles [192, p. 200].

Let's consider another related classification – the VARK typology of learning styles, which is based on individual features of information perception in the learning process, the so-called "sensory modalities of information perception" or "perceptual styles". The types of information perception considered within this classification are important and affect the ways and effectiveness of an individual's interaction with the information field.

The abbreviation VARK is used to describe a model that encompasses four sensory modalities of learning information perception by an individual: V – visual, A – auditory, R – based on reading/writing, K – kinesthetic [291]. The model was created as a development of the VAK model, which included visual (visual), auditory (auditory) and kinesthetic (motor) modalities [79]. The authors of the model, N. Fleming and K. Mills, developed a questionnaire to determine the preferred channels of information perception, the method of its use and interpretation of the received data [78].

We will describe the specified modalities:

1) Visual. Preference is given to information presented using maps, diagrams, graphs, block diagrams, hierarchies, etc. Design, space, forms and other ways of highlighting information are important. Such information does not include pictures or photographs, films, videos and presentations.

2) Auditory. Preference is given to the auditory channel of information perception (learning at lectures, group discussions, using mobile devices, web chats, etc.). This channel also includes talking out loud and talking to yourself.

3) Reading / writing. Preference is given to information presented in words. This method involves working with text - reading and writing in all possible forms, mainly manuals, reports, essays and assignments.

4) Kinesthetic. Real or simulated experience and practice are preferred in obtaining information. Such individuals have a strong connection with reality and the environment, so a specific phenomenon or object will be included in their experience only if it can be felt in any physical way [125, p. 102; 291].

Although one of the channels of information perception prevails in an individual, most people receive it from different channels with varying degrees of efficiency. The concept of multimodality was introduced to characterize a person who does not have one preferred way of perceiving information.

There are two types of multimodality: 1) the modality of the individual depends on the context: the individual uses the most effective channel for obtaining information for a specific situation; 2) the individual uses all the methods of perception inherent to him at the same time in order to obtain the most complete information and act on its basis [291].

This is consistent with the results obtained by O. Synekop, that students with a blended modality (visual, auditory, kinesthetic; visual, kinesthetic; visual, auditory; auditory, kinesthetic, etc.) can balance between different ways of perceiving information and freely change them depending on the situation [284, p. 45].

Another approach to the classification of cognitive styles is given in [91]. The authors provide a description of two personality dimensions that are involved in the process of interaction with information:

1) Method of obtaining information: perception, intuition. Perception-oriented individuals receive information from the senses that can be defined and measured, and rely on facts and concrete data. Intuitive individuals perceive information with their mind and are able to gain knowledge without using rational thinking.

2) Method of formulating conclusions: feelings (emotions), thinking. Individuals for whom feelings are of leading importance, make decisions guided by emotions, rely on human values and beliefs. Individuals for whom

thinking is of leading importance use logical reasoning to reach a conclusion, they are analytical and rely on data to make decisions [91, p. 79].

By combining the leading methods of obtaining information and formulating conclusions, four cognitive styles are distinguished:

1) Perception is a feeling. Individuals who make decisions based on facts and concrete data, but are guided by emotions; pay attention to details that are sensitive to the approval of other people.

2) Perception – thinking. Individuals who rely on concrete data and use the process of logical reasoning to formulate conclusions; to solve problems, they try to simulate the process.

3) Intuition is a feeling. Individuals who make decisions based on instincts and intuition do not use logical reasoning. They are creative and conceptual, but use their skills to meet the needs of others.

4) Intuition – thinking. Individuals who are interested in solving unstructured problems using logical thinking; perceive data as they may be, are capable of extrapolating facts, model problems to solve them [91, p. 79-80].

Many diagnostic methods have been developed in psychological science to determine the cognitive styles of an individual, the use of which requires prior training. Some of them are listed in Table 3.2.

Table 3.2. Diagnostic methods for determining the cognitive styles of higher education students in the process of a pedagogical experiment

Cognitive style	Diagnostic tools
Rigid / flexible cognitive control	The "Free Association" method (Gardner, Holtzman, Klein, Linton, Spence, 1959) [124, p. 69]
Field dependence / field independence	The "Included figures" method (Vitkin, Altman, Raskin, Karp, 1971) [124, p. 48] (Appendix A)
Narrow / wide range of equivalence	The "Free sorting of objects" method (R. Gardner) [171]
Tolerance for unrealistic experiences	Methodology "New Questionnaire of Tolerance – Intolerance to Uncertainty" (T. Kornilova) [184]
Impulsivity / reflexivity	The method of "Comparison of similar drawings" (J. Kagan) [124, p. 79]
Verbalization / visualization	Questionnaire for identifying verbal-visual thinking style (Richardson, 1977) [124, p. 93]

For the diagnosis of the cognitive style of *field dependence / field independence*, the technique "Included figures" (Vitkin, Altman, Raskin, Karp) is prescribed [124, p. 48]. Subjects are asked to find one simple out of five reference figures in thirty complex figures and indicate it. The total time of the task is recorded. The test results are evaluated by counting the number of correct answers and calculating the field dependence index. 1 point is awarded for each correct answer. If the index is greater than 2.5, it can be concluded about pronounced field independence, and vice versa, if the index is less than 2.5, this indicates pronounced field dependence.

For the diagnosis of cognitive style *narrow / wide range of equivalence*, the technique "Free Sorting of Objects" (R. Gardner) [171] is used. The participant is asked to arrange 75 real objects into groups in the most convenient, logical and natural way for him. Indicators of narrowness / breadth of the range of equivalence: 1) number of selected groups; 2) the number of objects in the largest group by volume; 3) the number of groups consisting of one object. The more selected groups, the narrower the range of equivalence. Representatives of the narrow style tend to focus on the differences of objects, paying attention mainly to their details and distinguishing features. Representatives of the broad style, on the contrary, tend to focus on the similarity of objects, classifying them taking into account some generalized categorical grounds.

For the diagnosis of cognitive style, *rigid / flexible cognitive control*, the method of "Free associations" (Gardner, Holtzman, Klein, Linton, Spence) is prescribed [124, p. 69]. During 5 minutes, the participant writes any words associated in his opinion with the stimulus word (for example, "house"). Answers are classified into 7 categories depending on the distance of each named word in relation to the stimulus word, for example: I – description of the house; II – internal structure of the house; III – what is in the house; IV – landscape around the house; V – the answers are distant in content, but related to the concept of "house"; VI – word play; VII – everything that does not belong to the house. The indicators of rigidity / flexibility of cognitive control include: 1) the length of the distance of free verbal associations; 2) total number of responses. The more distant the word association is from the stimulus word and the more of them, the more pronounced the flexibility of cognitive control.

T. Kornilova's "New Questionnaire of Tolerance – Intolerance to Uncertainty" was used 184]. The methodology contains 33 questions that must be evaluated from 1 to 7. After calculating the received points, the level of cognitive style tolerance to unrealistic experiences is determined, where 12-35 is a low indicator, 36-60 is average, 61-84 is high.

To diagnose the cognitive style of *impulsivity / reflexivity*, the technique "Comparison of similar pictures" developed by J. Kagan [124, p. 79]. The methodology consists of 2 training sheets, then 12 main sheets, on each of which there is an image of a familiar object (standard figure) on top, and 8 almost identical images of the same object are placed in two rows below, among which only one completely coincides with the figure- standard You need to find and specify an image that is completely identical to the reference figure. The evaluation takes place by calculating such indicators as: latency time of the first response (amount); total number of errors. Individuals with a reflective cognitive style are above the median response time and below the median number of errors, while individuals with an impulsive cognitive style are below the median response time and above the median number of errors.

Verbalization/visualization cognitive style, a questionnaire was used to identify the verbal/visual thinking style (Richardson) [124, p. 93]. The questionnaire includes 15 questions describing the situation of using one or another style. When answering "yes" to the question describing visual ability or advantage or to the question describing the lack of verbal ability or advantage, we get a score of "1", and a positive answer to the question describing verbal ability or lack of visual ability is scored as "0". The overall visualization tendency score is calculated by summing the scores for each question.

As it was shown in point 3.1, various aspects of professional training of future IT specialists and software engineers in institutions of higher education have been revealed in many scientific studies. The vast majority of these works are devoted to the formation of general and professional competences in them. Despite a significant number of scientific publications, the problem of the correlation of cognitive styles of future software engineers with their educational success in the process of professional training in educational programs of the first (bachelor) and second (master) levels

in institutions of higher education in the domestic pedagogical theory is currently insufficiently researched. In our opinion, this is connected, in particular, with the general methodological problem formulated by S. Maksymenko and D. Pasichnik: "can cognitive styles determine not only methods of activity, but also its productivity, success, effectiveness" [162, p. 6].

The peculiarities of the manifestation of cognitive styles, their influence on success in the process of studying computer sciences and the professional activities of IT specialists, in particular programmers, possible approaches to taking into account the cognitive styles of an individual in order to create conditions for effective activity were investigated by Zh. Wilson [319], L. Kaprez and F. Ahmed [50], J. Myers and B. Münzinger [179], J. van Merienbor [309], H. Sterling and T. Brintaut [271], M. Chilton, B. Hardgrave and D. Armstrong [55], H. White and M. Sivitanides [317] and other scientists.

In particular, J. van Merienbor presented the results of a study aimed at studying the relationship between the cognitive style of impulsivity / reflexivity and success in the process of learning an initial programming course. The author shows that students with a reflective style showed better results in taking a program comprehension test than students with an impulsive style. At the same time, no significant differences were found according to the results of the test on the actual knowledge of features and syntax of the programming language. These results allowed us to conclude that the reflective strategy contributes to the development of patterns for solving specific programming tasks. The author also put forward a hypothesis that educational materials, oriented not on writing programs, but on their reading, modification and improvement, will contribute to the transition of students from an impulsive to a reflective strategy, which will ensure better educational results [309, p. 181].

H. White and M. Sivitanides investigated the possible influence of cognitive personality characteristics on difficulties in learning specific programming languages. They considered the differentiation of cognitive styles according to views on the asymmetry of the cerebral hemispheres and, in particular, established that when studying procedural programming, "left-hemisphere" students demonstrate better results, when studying script

programming languages (JavaScript, etc.) – "right- hemisphere" students, when studying object-oriented and visual programming – both groups of students. In addition, the researchers concluded that taking into account cognitive characteristics will contribute to the improvement of students' academic performance [317].

The work [208] presents the results of an experiment on the study of the labor productivity of IT specialists taking into account several factors, in particular, cognitive style. This study uses Kirton's bipolar model – adaptive / innovative cognitive styles. People with an adaptive cognitive style mostly work in a systematic and well-structured way, prefer clear and stable situations. Unlike them, people with an innovative cognitive style are prone to non-standard and creative behavior [208, p. 240]. One of the results of the study was the conclusion that IT specialists with an innovative cognitive style show different productivity in standard and non-standard situations [208, p. 249].

As shown in scientific publications, the successful performance of production tasks in the IT industry directly depends on the individual characteristics of the individual, and therefore on the cognitive style. The situations in which this style appears are also important. In this regard, the implementation of high-quality and effective professional training of future software engineers in institutions of higher education according to educational programs of the first (bachelor's) and second (master's) levels in specialties of the field of knowledge 12 Information technologies requires taking into account the cognitive styles of students of higher education, since their educational and further professional activities involve performing numerous operations with information using various ICT tools.

Based on the above definitions of cognitive styles, taking into account their features, as well as the results of scientific research devoted to the cognitive styles of IT specialists, we formulate the author's interpretation of the concept of "cognitive style of a software engineer". We consider the *cognitive style of a software engineer* as characteristic models of his interaction with the information field and information processing, in particular perception, conscious reasoning, memorization, understanding of the world in general, which are used in the process of educational and professional activities. The specificity of these models

is determined by the features of the information field of the software engineer, which were characterized above.

Therefore, in order to ensure effective activity and professional self-realization of a software engineer, it is necessary to create external conditions that contribute to the manifestation of his specific ways of perceiving, processing and using information. In this regard, in the process of professional training of students of higher education under bachelor's and master's educational programs, it is advisable to pay attention to the definition of their cognitive styles, the formation of their understanding of their own peculiarities of information perception and the ability to act productively taking into account this understanding.

In the process of performing this task, a number of problematic questions arise, namely: whether there is a direct connection between the academic performance of students and their cognitive styles; how to determine the cognitive styles of students of higher education; how to form in them an understanding of their own information processing models and the ability to effectively apply them in specific practical situations; to what extent it is necessary to take into account cognitive styles in learning situations and how much the educational environment should correspond to these styles; which approach to give preference to – creation of the most favorable conditions for the manifestation of cognitive styles of higher education seekers or conditions for the formation of other models of interaction with information.

3.3. Forms, methods and means of intensification of professional training of future software engineers

An integral element of the organization of the educational process in higher education institutions is the use of a system of forms, methods and means of learning to achieve the set goals.

The form of organization of education, as noted by M. Fitsula, is "an external expression of the coordinated activity of the teacher and students, which is carried out in a prescribed manner and in a certain mode" [77, p. 155].

Within our study, the main *forms of education* were chosen as educational classes (lecture and laboratory), blended and distance learning, independent work of students of higher education, control measures. Intensification of professional training of future software engineers in classroom classes was carried out by increasing the information capacity of the educational material. In order to solve this task, the content of training was updated, its fundamentals were strengthened, as well as compliance with modern trends in the field of information technologies.

In addition, in order to intensify the classroom lessons, following the instructions of O. Pshenychna [233], we used the presentation of educational information in the form of presentations, in particular non-linear, and web documents. To intensify independent work, students of higher education were given tasks to find additional materials, prepare short reports on current topics (for example: "Development of mobile applications: yesterday, today, tomorrow", "Programming paradigms: friends or competitors", etc.), independent development separate methodical materials (test questions for knowledge monitoring), etc.

Among the forms of organization of the educational process, a special place belongs to blended learning, which is based on the use of distance educational technologies, as well as to distance learning itself, which has acquired special significance during the period of the COVID-19 pandemic. Domestic scientists developed theoretical and methodological guidelines for the implementation of distance and blended learning, considered numerous problems, in particular, related to the quality and efficiency of the educational process, its methodical, organizational and technical

support. The results of these studies are presented in the publications of V. Bykov, Yu. Bogachkov, K. Bugaichuk, T. Vakalyuk, N. Valko, S. Voloshinov, V. Kruglik, V. Kuharenko, V. Osadchyi, K. Osadcha, O. Rybalko, O. Spirin and other scientists.

Distance education can be considered as a type of educational system (mainly distance technologies are used to organize training) or as a form of education [48, p. 8]. Without resorting to a detailed analysis of its characteristics, we will only give a definition: "Distance learning is the interaction of a teacher and students with each other at a distance, which highlights all the components inherent in the educational process (purpose, content, methods, organizational forms, means of learning) by specific means of the Internet technologies" [149, p. 3]. In turn, blended learning is a combination of traditional and distance learning, which can take place in any form and to any extent [149, p. 52].

V. Kukharenko, summarizing the work of foreign researchers, names the following types of mixing in the educational process: mixing face-to-face and distance learning; mixing of structured (characterized by the presence of specially developed educational materials and provided learning trajectories) and unstructured (through conversations, meetings, etc.) learning; mixing user content and external materials; mixing independent and collaborative learning; mixing work and study [149, p. 54-55].

So, blended and distance learning are currently not new or poorly studied forms of the educational process, but it is worth noting the insufficient level of its development in the vector of speeding up learning and improving the quality of teaching. That is why the improvement and search for new approaches to the organization of blended and distance learning is one of the priority areas of work of teachers of higher education institutions. One of such problems that needs an urgent solution is the intensification of distance education and the adaptation of its environment to the manifestations of cognitive styles of higher education students, since not enough similar studies have been conducted, and practical developments have not become widespread in domestic higher education institutions.

General proposals for adapting the design and means of distance education to achieve the goals of intensifying the professional training

of future software engineers, taking into account cognitive styles at different stages.

Planning the educational process. The general activity of the teacher at this stage can be focused on taking into account the cognitive style characteristics of higher education students. This work includes:

1) Audience analysis. The teacher's task is to use the appropriate tools to diagnose the cognitive styles of students. The teacher must be sure that he knows the main styles of interaction of students with the information field.

2) Terminal goals. They should be comprehensive to meet the cognitive style characteristics of the maximum number of students. In order to maximize the potential success of the group, the final goals should be formulated taking into account the cognitive styles of future software engineers, as well as be oriented to the diversification of the manifestations of these styles in educational and professional activities or to change in the case of the need to achieve better results.

3) Instructional training. After identifying students' cognitive styles, it is necessary to prepare methodical materials, the use of which will ensure unity between the stylistic characteristics of the students and the educational content and teaching methods, which will contribute to the intensification of professional training.

Building an educational environment, namely the creation of physical and / or psychological conditions that will contribute to the professional growth of future software engineers. At the same time, it is necessary to take into account two important aspects: remote contact and cognitive styles.

"Remote contact" means that students cannot directly communicate and interact face-to-face with the instructor or other students, so the onus is on the instructor to create a supportive environment and ensure timely online contact and assistance. Distance contact and assistance involve two main types of interaction: student-student (contact with colleagues is an important factor in improving academic results, increasing academic stability and motivation to finish the course) and teacher-student (active interaction with the teacher creates a situation of trust in the course and motivates to its completion).

The "cognitive styles" aspect consists in the adaptation of the distance education environment (learning platform, course content, sequence

of studying individual topics, methods of interaction, etc.) to the cognitive styles of higher education students. Taking into account this aspect involves the quality selection of educational materials and methods of interaction, as well as creates conditions for a quick response to changes in the academic performance of applicants. For example, if we rely on D. Kolb's model of learning styles, then it is advisable to provide mainly theoretical materials to students with an assimilative style, and to students with an accommodative style – mainly training based on a project approach, which in the case of professional training of future software engineers consists in the development of software products, to students with a convergent style – to provide abstract information, with a divergent style – concrete information. If the VARK model is taken into account, then it is advisable to provide verbal versions of the material, as well as verbal material for conversion into image form, and provide visuals with concrete analogies of abstract ideas. Based on the classic bipolar classification of cognitive styles, it is possible to offer mainly individualized training for field-independent higher education seekers and group training with active cooperation for field-dependent ones.

Next, we will give recommendations, the observance of which will contribute to the intensification of distance learning of future software engineers in higher education institutions:

1) Correspondence of the content and method of presentation of educational materials to the cognitive styles of higher education applicants. These materials should be rich in information, convey the complexity and fundamental content of the academic discipline.

2) Alignment of teaching styles with cognitive styles of students of higher education: compliance of the educational strategy with the style of field dependence / field independence; correspondence of the conceptual structure and layout of materials to the holistic and analytical style; matching the choice of presentation mode with sensory preferences; compliance of educational materials with the profile of the lateral organization.

According to the definition given by M. Fitsula: "Teaching method is a method of orderly interrelated activities of teachers and students aimed at solving the tasks of education, upbringing and development in the learning

process" [77, p. 118]. Within the framework of our research, such a task is the intensification of the professional training of future software engineers.

In the process of designing *a system of training methods*, we relied in particular on the research of domestic scientists on the problems of professional training of future software engineers. In these studies, the peculiarities of the use of such methods are characterized, such as: method of problem-based learning [308], explanatory and illustrative method [308], research method [308; 144], heuristic method [308], project method [308; 137; 138; 141; 144], the training method of learning [137; 141], performance of educational and training exercises [138; 141; 144], interactive methods [14; 138; 141], adaptive learning [137], modeling of situations [137; 144], testing [137], methods of improving basic IT products and creating new IT products [16], strategy of cognitive conflict [144], method of building mental models [144], etc.

The basis of learning the disciplines of the professional training cycle is *the project method*, which involves the consistent implementation of practice-oriented project tasks during the study of a specific discipline. A mandatory aspect of the educational interaction between the teacher and students of higher education is the use of the proposed set of modern software tools that support both different aspects of the educational process and the stages of designing and creating the final software product. As the requirements for the project being developed are clarified, future software engineers are obliged to independently expand their knowledge of the theoretical aspects of software development and the characteristics of the software tools used for implementation. This approach contributes to the development of inductive thinking, the mastery of technological and informational skills, the formation of readiness for independent problem solving, creative skills for solving large tasks, the ability to self-educate using various information resources, and the formation of research skills.

The above-described approach to the organization of the educational process involves active interaction between the teacher and the student, the use of modern technologies during lectures and laboratory classes, and support for independent work in student groups. The basis of the interaction between the teacher and the students of higher education is mutual respect, support for non-standard solutions in the process of completing assigned

tasks, compliance with cultural norms and rules of behavior that have developed in society. The teacher plays the role of the main coordinator of the educational process, who agrees on the composition of groups for the implementation of project tasks, assigns individual tasks to groups, provides interim consultations and performs ongoing control, organizes the presentation of projects to possible users and customers at the final stage.

The experience of organizing project activities of future software engineers made it possible to formulate some guidelines:

1) According to the student-centered approach, when forming groups, it is necessary to take into account the cognitive styles of students of higher education, their psychological compatibility (desire of students to work together), academic success, priorities regarding the topic of the task to be solved, subject area, instrumental means of implementing the software product, forms of interaction within groups and others.

2) To ensure an intensive educational process, introduce separate theoretical problems for deepening knowledge, for example, from an object-oriented approach or data analysis (increasing information capacity and fundamentalization of educational content), offer interdisciplinary projects or additional tasks within monodisciplinary projects (integration of the content of adjacent disciplines), to propose the development of projects using the most relevant technologies, even those that were not used in the educational process (taking into account modern trends in the development of information technologies).

3) When conducting training sessions, modern educational technologies should be used, which support all stages of work on individual projects, provide multimedia lectures and interactive individual consultations, project work planning, support for collective work on projects.

4) When forming the topics of the projects, it is necessary to bring them as close as possible to real production tasks or scientific research works, which will not only allow students of higher education to develop certain skills and abilities, but also familiarize them with the complexities of real professional activity, as well as motivate them to choose and specification of the field of further employment.

In the process of organizing the project activities of future software engineers, we used *the eduScrum technology*, which is popular in higher

education as a method of professional training of highly qualified specialists. Features of the method are characterized in domestic publications [122; 180] and foreign scientists [51; 67; 299; 318].

The eduScrum method is a version of the Scrum project management method adapted to the educational environment, which is a framework for active learning in collaboration and co-creation. The teacher formulates tasks, provides help and advice. Students perform tasks in a fixed rhythm, plan their own activities and monitor their own progress. Therefore, the application of the method allows to move from education managed by teachers to education managed by learners, when they are the owners of their learning process. The result of such an organization is the formation of students' internal motivation and interest, their personal growth, obtaining high academic results [318, p. 97]. The main rule of eduScrum is that students should work in a team that creates a high-quality software product as a result, that is, not only the process, but also the result of activity is important [299, p. 650].

The implementation of the eduScrum method involves the use of special terminology, namely: the product owner is a teacher who controls the educational discipline; eduScrum team – a group of students that uses the eduScrum method during project implementation; eduScrum master-student – head of the eduScrum team; a list of tasks to be completed; sprint – a stage of the project, the deadline for submitting the results of the stage [299, p. 650].

The teacher – the owner of the product sets the task (formulates the requirements for the software product, the general term of work, the task and the duration of individual sprints). Students make a list of tasks to be completed during the sprints and place it on the eduScrum board (it can be a poster, a flip chart, but nowadays special software tools are mostly used, such as the cloud web service Trello). During work, each task moves between the categories "do" – "in progress" – "requires verification" – "completed", which visualizes the process of project implementation and its dynamics. Since the Scrum method is used to manage projects in the field of software development, the use of its educational version for the professional training of future software engineers is expedient, as it allows you to bring the project activities of higher education students

closer to the realities of the IT industry, immerse them in professional activities.

The apprenticeship method adapted by V. Kruglyk, *the method of building mental models* and *the strategy of cognitive conflict* [144]. It turned out that the result of the application of these methods is closely related to the methods of obtaining and processing information inherent in higher education students. The use of these methods in the educational process, on the one hand, contributes to its intensification by accelerating the assimilation of new information and transferring it to the internal plan to the level of knowledge, and on the other hand, it creates conditions for future software engineers to realize their cognitive features, their weaknesses and strengths, the manifestation in various life and professional situations.

The essence *of the cognitive conflict strategy* is that in the process of professional training, future software engineers constantly receive new information, which in some cases may contradict their existing knowledge and understanding. Then situations of cognitive conflict arise, which are uncomfortable for the individual, so students of higher education try to overcome them by achieving consistency of the internal knowledge system with new information [144, p. 231].

Personal strategies for overcoming such a conflict are diverse, for example: individuals intolerant of unrealistic experiences may deny new information, refuse to use it; individuals with an impulsive cognitive style may too quickly accept or reject new experiences without the necessary consideration. In the process of studying programming, such situations occur quite often, for example: when considering dynamic typing and syntax features of the Python programming language; when studying anonymous functions; when considering the possibilities of the JavaScript programming language for the development of server applications, etc. Therefore, the teacher faces a number of tasks: 1) control the emergence of situations of cognitive conflict and help students of higher education come out of them with new knowledge; 2) provide the necessary assistance taking into account the cognitive styles of students; 3) artificially create such situations for future software engineers to acquire new knowledge.

The essence *of the method of building mental models* is that in the process of professional training, teachers encourage future software engineers to independently form mental (mental) models when learning new concepts and theories, as well as at the beginning of practical tasks, in particular project ones [144, p. 229]. In general, a person constantly creates mental models in the process of learning or professional activity, but often this happens spontaneously, unsystematically. As a result, models may not correspond to reality, be incorrect. In order to prevent such situations, students should be required to build models, present them verbally or visually, and discuss them. Gradually, as a result of such practice, students of higher education develop the ability to freely build and operate mental models, which is important for software developers, since they have to predict the structure and behavior of programs. The significance of this method for intensifying the professional training of future software engineers is that the presence of mental models facilitates and accelerates the understanding of related theoretical concepts and program design, increases the duration of storing theoretical information in memory, which allows to increase the information capacity of educational disciplines.

The essence *of the apprenticeship method* is that the process of skill formation consists of successive stages: 1) the teacher demonstrates practical programming techniques; 2) students of higher education perform practical tasks under the guidance of a teacher; 3) students of higher education perform practical tasks independently [144, p. 228]. This method is necessary for mastering software engineering skills, but its application requires quite a lot of time. For the purpose of intensifying the professional training of future software engineers, we combine the apprenticeship method with *the mentoring method*, where more experienced students of higher education (mostly those who obtain a master's degree) provide assistance to less experienced ones. At the same time, mentors have to deepen their own knowledge, since a wide variety of questions arise during counseling. This method was implemented by us during the organization of project activities for students of higher education.

In the process of teaching academic subjects, it is also advisable to use *interactive teaching methods* (trainings, brainstorming, case studies, etc.), which is now one of the important conditions for organizing a high-quality

educational process, as it does not allow students of higher education to play the role of passive recipients of information.

Interactive learning involves constant, active interaction of all participants in the educational process, when the student and teacher (student and teacher) are equal subjects, understand what and why they are doing, and reflect on this activity [219, p. 9].

As S. Sysoeva notes, the use of interactive methods in the process of teaching adults (and higher education students belong to this category) allows to intensify understanding, assimilation and creative application of knowledge, increases motivation to solve educational problems, provides experience of dialogic communication with the world, contributes to the formation of professional competencies [286, p. 38-39].

Although under the conditions of the implementation of the interactive learning model, a significant amount of time is spent on studying a small amount of information, the percentage of assimilation of the material is mostly high, and the acquired skills can be used by learners in any situations outside the educational institution [219, p. 14-15].

For example, in the process of determining topics for group educational projects, modified *training exercises "Problem search"* and *"Causes and solutions" were applied* [295]. *The "Problem Search" method* [295, p. 93] consists of the following: in the audience, illustrations or text inscriptions are laid out on tables or chairs (preferably drawings, as they mostly cause a more emotional reaction and interest of the participants), reflecting the possible subject of the projects.

Every student of higher education should choose a topic that interests him. If none of the topics aroused interest, you can suggest your own (draw a sketch, diagram or make an inscription). Next, students present topics at a group discussion, find like-minded people and, at the end, join groups for further work on projects. *Method "Causes and Solutions"* [295, p. 94] is that future software engineers are asked to draw a “problem tree”. Its trunk is a clearly formulated problem that can be solved by developing a software tool, its roots are possible causes of the problem, and its branches are possible solutions. The participants of the discussion choose an interesting problem for them and "create" their tree, and then present it, clarifying the essence of the problem, its causes and ways to solve it.

In the process of work aimed at studying and taking into account the cognitive styles of students of higher education in the process of professional training, as well as forming in them the ability to understand their stylistic features and those of other group members, to be tolerant of possible manifestations during joint activities, it is advisable to use *the training method*. Achieving the goals of intensifying the professional training of future software engineers using this method is ensured indirectly: during trainings, students get to know themselves better, their capabilities and the capabilities of others, learn to take this knowledge into account in their activities, in particular educational, to achieve their effectiveness.

Academic trainings are suggested by scientists to be considered as a form or method of professional training, as well as a pedagogical technology. As a method of education and professional training, training is a system of specially organized classes that have a common structure and didactic space and whose goal is a comprehensive analysis of various situations [173, p. 15]. The following methods are most often used in the training process: mini-lecture; demonstration; problem-based discussion; individual tasks; situational tasks; simulation activity; business (management) games; work in small groups; testing; presentations; "brain storm" [286, p. 130-137].

In the Table 3.3 provides a comparative description of traditional education and the training method, based on the materials of the work [187]. Analyzing the given information, we conclude that teaching in higher education institutions is currently close to training in terms of didactic characteristics, as it involves the use of various interactive methods, the active participation of students of higher education, and reliance on their experience.

During the research, training sessions were held for future software engineers aimed at studying their cognitive styles. Training duration: 4 astronomical hours. Structure of the training:

I. Introductory stage:

- familiarization of the participants with the training regulations;
- adjustment to work, formulation of goals and expectations;
- formulation of rules of behavior and interaction to create a safe, comfortable and creative atmosphere.

Table 3.3. Comparison of traditional training and the training method [187, p. 9]

Characteristic	Traditional education	Training method
Approach to communication	One-way (from teacher to students)	Bilateral with the active participation of all present
Source of knowledge	Teacher	The coach guides the process, but is not the only source of information
Goal	Transfer of knowledge	Transfer of knowledge, formation of skills, attitudes
Physical environment / seating plan	Row after row	Any seating, convenient for communication
Methods of submitting material	Lecture, reading assignment	Role-playing games, case studies, experiments, discussions, problem solving

II. The main stage:

- mini-lecture "What is cognitive style";
- a moment of relaxation (exercise is an energizer to relieve fatigue);
- mini-lecture "Manifestations of cognitive styles in the life and professional activity of a programmer."

III. Break.

IV. The main stage (continued):

- settings for individual work;
- implementation of methods for diagnosing cognitive styles;
- a moment of relaxation (exercise is an energizer to relieve fatigue).

V. Break.

VI. The main stage (continued):

- activation of participants' activities, preparation for working in groups;
- simulation of situations of manifestation of cognitive styles in small groups, theatricalization;
- a moment of relaxation (exercise is an energizer to relieve fatigue).

VII. Break.

VIII. The final stage:

- reflection "Training results": analysis of new knowledge and understanding;

- reflection "Participants about the training and the trainer": feedback from the participants about the results of the training (whether the expectations formulated at the beginning of the work were realized) and the trainer-teacher,

- reflection "Trainer about training": the most successful and interesting moments of the training, formulation of conclusions and proposals for further work.

In the training process, not only interactive teaching methods are necessarily used, but also special training exercises designed to activate interaction in a group of participants (acquaintance, expectations, energizers, group dynamics, etc.).

Also, trainings aimed at studying cognitive styles were held for those obtaining a master's degree using the "*Synanon method*", characterized in the works of N. Myronchuk [180] and T. Turcot [301]. Such training is a business game, during which participants interview several selected students on certain theoretical material or on the results of a software product development project. During the interview, you can ask any questions, in particular, those that provoke the interviewee to an emotional reaction (difficult, critical, unexpected). The ban applies only to offensive personal characteristics and outright rudeness. The teacher acts as a moderator of the game and analyzes the results and behavior of the players at the end. A group of experts also participates in the training, who evaluate the correctness of the answers, the quality of the software product presentation, the emotional stability of the interviewee, and also monitor the course of the game and the duration of the interview of one student (no more than 5 minutes). Experts can be students of higher education or invited teachers. You can interview individual participants (theoretical interviews) or representatives of small groups (interviews based on the results of project activities). The specifics of the training, taking into account the goals of our research, are as follows:

1) At the beginning of the training, it is necessary to conduct a mini-lecture and familiarize students with specific cognitive styles, their manifestations, weaknesses and strengths.

2) Based on the information received, the training participants must independently determine the leading cognitive styles of the interviewees and formulate questions, trying to hit their weak points.

Conducting trainings using the "Synanon method" contributes to the familiarization of students of higher education with cognitive styles, the formation of their ability to adapt to difficult situations and emotional stability.

The modern student-centered educational environment does not have strict restrictions on the methods of activity, therefore, future software engineers who study under educational programs at the bachelor's and master's levels have the opportunity to solve educational and professional tasks, relying on the cognitive styles already formed in them, which contributes to the formation new understandings and knowledge, development of professional outlook and scientific outlook. At the same time, the professional training of masters is characterized by certain differences, since they already have a higher education with a bachelor's degree, mostly in the specialties of one field of knowledge, and therefore experience in educational and practical activities, as well as formed views on professional activity and professional attitudes.

Taking this into account, in order to achieve the goals of the research, i.e. to provide intensive professional training taking into account the cognitive styles of higher education students, we chose the following strategy. Within academic disciplines that may require students to make mental efforts and develop non-trivial approaches to solving problems, for example: "Expert technologies for decision support systems", "Neural networks" or "Modern problems of artificial intelligence", it is advisable to build the educational process with support on leading methods of intellectual behavior and interaction with the information field. In the process of developing educational and research projects, students should be grouped into microgroups based on the principle of combining performers with different stylistic features to achieve synergy.

At the same time, the requirements for specialists who have obtained a master's degree, formulated in the National Framework of Qualifications and Standards of Higher Education, determine the relevance of training future software engineers in educational programs of the second (master's)

level for activities in situations where it is necessary to identify different methods of interaction with the information field, in particular those that are not specific to a specific personality. For this purpose, we consider it expedient when studying disciplines from which students of higher education have already formed the foundation of professional training, have certain knowledge and skills (for example, "Development of mobile applications", "Modern web technologies", "Management of software projects", etc.), create more complex conditions that will encourage them to use unusual models of intellectual behavior. Let's give some examples.

Psychological studies have shown that field-independent students better identify the structure of texts and reorganize them, the result of which is the construction of clear hierarchies of conceptual information of academic disciplines [162, p. 8]. For field-dependent students of higher education, such activities are mostly a significant problem, therefore it is advisable to offer them the task of constructing diagrams of connections, precedents, etc., drawing up structural and logical schemes based on lecture material, writing quintessences of research, etc.

The cognitive style "narrow / wide range of equivalence" characterizes individual differences in orientation to the similarity or difference of objects in the process of their categorization. Taking this into account, it is advisable in the process of formulating tasks to set strict requirements for the classification of certain objects, for example from the discipline "Development of mobile applications": to develop a typology of tools for creating the user interface of mobile applications in the Android Studio environment, to take grouping according to three characteristics as a basis. Another version of the task: develop a mobile application "Calculator" using ten control elements to create an interface; justify your decision if the number of elements is not equal to ten.

Impulsivity / reflexivity under conditions of uncertainty, when a choice must be made from a set of alternatives, belongs to the cognitive styles whose influence on the success of educational and professional activities is the most obvious. Impulsive people tend to react quickly and make hypotheses without analyzing alternatives. Reflective individuals react slowly, pre-formulating and testing many alternative hypotheses [124, p. 79]. Taking this into account, impulsive students of higher education should be offered to necessarily formulate

several alternative solutions to the same task, even if the first one turned out to be successful. For reflective students, on the contrary, it is possible to limit the search time and the number of analyzed alternatives.

We note that when applying each of the mentioned approaches, there is a risk of a temporary decrease in the educational success of those seeking higher education, since they will have to act in an atypical way. However, they contribute to students' recognition of their own personalities, the formation of their ability to adapt to new circumstances of educational and professional activities, readiness for professional mobility and other changes, and in general, the diversification of their cognitive styles. However, achieving such a result is possible only on the condition of preliminary pedagogical modeling, diagnosis of cognitive styles of higher education seekers and prompt response to difficulties that may arise.

In this regard, we will formulate some recommendations for the use of these strategies in the process of professional training of future software engineers in educational programs of the second (master's) level in specialties of the field of knowledge 12 Information technologies:

1) It is necessary to carry out a diagnosis of the cognitive styles of students of higher education and to familiarize them with the obtained results. If they do not sufficiently understand the essence of this concept, conduct explanatory work with the involvement of psychologists. The form of such work can be training.

2) Diagnosing the ability of students of higher education to adapt to changes and difficult situations. Depending on the results, choose one of the strategies.

3) The organization of training based on a strategy that requires future software engineers to use unusual models of intellectual behavior can be done by introducing individual tasks or you can build a course entirely on this basis.

4) Before the introduction of the specified strategy, it is necessary to explain the goal and expected results to those seeking higher education.

The main *means of professional training of* future software engineers were various software tools (web-oriented, for personal computers, for mobile devices) of professional purpose, which is explained by the peculiarities of the future professional activity of graduates. Among such environments, we will single out learning management systems, means

of submitting educational materials, means of monitoring educational achievements of higher education applicants, means of online communication, means of conducting classes in the mode of video conferences, web services for joint work, integrated software development environments, etc.

LMS plays an important role in the educational process Moodle, on the basis of which the distance learning system at Bohdan Khmelnytskyi MDPU functions. With its use, such tasks as: training management, presentation of educational materials, control of educational achievements of higher education applicants, online communication, conducting classes in the mode of video conferences are solved. Third-party Oracle resources were also used to deliver the training materials Academy and Coursera. To organize the joint work of future software engineers in the process of implementing educational projects, the GoogleDocs service was used (for exchanging documents, performing individual tasks), Trello and Redmine services (for project management), GitHub (for hosting IT projects and joint work on them).

Among the training tools that were used in the process of professional training of future software engineers to achieve the goals of its intensification taking into account the cognitive styles of students of higher education, we will single out online communication tools. These tools were implemented as an element of the overall design of the distance learning system to organize effective teacher-student and student-student interaction.

In the process of choosing the most convenient means, a number of requirements for means of remote communication were formulated, namely: creation of conditions for conducting practice-oriented individualized lectures, laboratory and practical; motivation of students of higher education to study the subject component through multimedia world perception during the educational process; their motivation for independent learning and professional self-improvement; establishment of synchronous interaction between the teacher and future software engineers; involvement of higher education students in the creation of a personal information environment.

We have analyzed several means that are expedient to use to organize the educational process in higher education institutions. The obtained results are shown in the Table 3.4.

Table 3.4. Comparative characteristics of means of remote communication

Function	Skype	TrueConf	Hangouts	Discord
Individual text messages	+	+	+	+
Conference text messages	+	+	+	+
Individual calls	+	+	+	+
Conference calls	+	+	+	+
Screen broadcast	+	+	+	+
Multi-threaded screencasting	-	-	-	+
Setting user rights	+\-	+\-	-	+
Creation of parallel channels	-	-	-	+
Connecting bots	-	-	-	+
Limits on the number of users	-	-	-	-
Limitation on the number of simultaneous video conference participants	25	-	-	50
Ability to control users	+	+	+	+
Setting voice priority	-	-	-	+
Report on user activity	-	-	-	+
Server moderation	-	-	-	+
Creating a separate server	-	+	+	+

Taking into account the results of the conducted analysis, it can be stated that the software tool Discord has advantages in creating conditions for the synchronous educational process. A problematic aspect of Discord is the limitation of the number of users per video broadcast channel, but since such classes are mostly held in groups of up to 30 people, this factor can be considered non-critical.

Here are the main characteristics of Discord, which are important for the organization of intensive professional training of future software engineers: creation of an unlimited number of servers; setting the interface language and general information about the server; creation of an unlimited number of text and voice communication channels; inviting new users (invitation-link, invitation from the list of friends, invitation by creating

a widget for the site); user role settings; setting access rights for various communication channels; audit log and moderation; fixing messages for each of the channels; conducting live broadcasts; management of users' means of communication.

So, we have defined a system of forms, methods and teaching tools that were used in the educational process. It is shown that all forms of education organization are subject to intensification: training sessions, independent work of higher education students, control measures. This is achieved by adjusting the content of training in accordance with the developed organizational and methodical principles and activating the cognitive activity of future software engineers using a number of methods and means of training. Examples of the application of the project method, eduScrum technology, the apprenticeship method, the method of building mental models, the strategy of cognitive conflict, and interactive learning methods in the educational process (trainings for studying cognitive styles, training exercises, "Synanon method") are given. A list of training tools is provided, which should be used to ensure intensive practice-oriented professional training of future software engineers.

CONCLUSIONS

The application of information, communication and digital technologies in higher education in order to improve the quality of professional training of future specialists is currently one of the priority areas of its development. ICT tools provide the participants of the educational process with various opportunities, contributing to the strengthening of its individualization and personalization. These approaches have now become extremely important, since taking into account the individual characteristics and educational needs of the learner allows teachers to get closer to achieving the primary goal – the formation of an individual who has a complete set of general and professional competencies. In view of this, the problem arises of providing the educational process in general and its individual elements with adaptability, that is, the ability to make flexible changes depending on the specific conditions of its course. Despite the availability of many scientific studies dealing with adaptive learning, the practical aspects of its implementation at higher education institutions require further development.

The monograph presents the results obtained by the team of authors during the implementation of the National Research Development Program of the Department of Informatics and Cybernetics of Bogdan Khmelnitsky State Pedagogical University "Adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning" (state registration number: 0120U101970).

The conducted research has made it possible to draw the following conclusions:

1) The content analysis of scientific publications dealing with the problems of adaptive and personalized learning using ICT tools has been carried out. It has been shown that the person-oriented approach is sufficiently well developed in the world pedagogical theory and practice, however, certain aspects remain insufficiently researched, which is related in particular to the need to deepen the understanding of the psychological mechanisms of learning using ICT tools. In this regard, scientists continue to search for new ways to achieve the maximum degree of compliance of education with the requests and capabilities of the individual. Personalized

and adaptive learning provide such an organization of the educational process, in which a comprehensive study of the learner's personality is first carried out, then a model of their possible development is created, and subsequent influences and interactions are built taking into account this model, which is dynamic and subject to adjustment. Modeling the learner's personality is based on data on peculiarities of their educational activity, the collection and further processing of which is a complex, resource-intensive process that requires the involvement of specialists in various scientific fields, as well as the use of information and communication technologies. The development and implementation of adaptive learning systems, in particular based on the application of intelligent information technologies, aim to increase the efficiency of all the mentioned operations and provide access to personalized education for all citizens. The organization of the educational process in a distance form actualizes research on the problems of applying adaptive learning systems, among which it is appropriate to highlight such directions as: improving the functionality of existing learning management systems, in particular the Moodle platform, providing them with means of personalized and adaptive learning; professional training of specialists (psychologists, teachers, tutors) to use these systems at formal and informal education institutions.

2) The analytical review has been performed and the classification of adaptive learning systems has been clarified. It is shown that the advantages of using adaptive learning systems include: reducing unproductive labour costs of teachers; providing students with opportunities to freely choose their study trajectory; applying the differentiated approach to students taking into account their available experience; increasing the effectiveness of control and evaluation of training results; increasing learning motivation, etc. The content analysis of scientific sources has shown that the following main types of adaptive learning systems are currently distinguished: macro-adaptive; microadaptive; interactive systems that take into account the abilities of students; intelligent tutoring systems; adaptive hypermedia systems; adaptive educational hypermedia systems; adaptive learning platforms; adaptive learning platforms with machine learning; systems of computer adaptive educational assessment; and systems of educational facilities. Using data available on the Internet, 30 adaptive

learning platforms have been analyzed, on the basis of which comparative tables have been developed. The main parameters according to which the comparison has been made are the following: the type of system; tariff plans; availability of implementations for mobile devices and personal computers; use of cloud technologies; functionality (use of competency frameworks; course development toolkit; integration with LMS; use of natural language text processing technologies; implemented elements of adaptability); compliance with the principles of pedagogical design; quality of usability and ergonomics of the user interface. The obtained results have formed the basis for the further development of a model of the adaptive system for the individualization and personalization of professional training of future specialists under conditions of blended learning.

3) In the process of research, the modeling of the adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning has been carried out, as a result of which the concept and model of this system, as well as a model of blended learning in a higher education institution, have been developed.

The concept of the adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended learning defines the main idea, goal, task, methodological approaches, organizational and pedagogical conditions of the functioning of the adaptive system for the individualization and personalization of professional training of future specialists under the conditions of blended training. The concept is based on systematic, adaptive, synergistic, cybernetic, environmental, individual, competence, activity, complex, technological and student-centered methodological approaches. Its main idea is based on the fact that ASIPPT should be built on the basis of the complex and systematically determined use of modern information and communication technologies and forms, methods, means and technologies of learning at higher education institutions to ensure adaptive learning, the individual and personalized approach in the process of professional training of future specialists. The purpose of ASIPPT is to use a flexible informational and educational environment that provides teachers and students with different individual characteristics and personal preferences with the means to improve professional training.

In the modeled adaptive system for individualization and personalization of professional training of future specialists under conditions of blended learning, adaptability is planned to be implemented by adapting educational materials, control, devices, face-to-face classes; individualization – study of individual qualities of students, support and accompaniment of the individual educational program of the student, individualization of the learning process, development of the individual characteristics of the student and the formation of new characteristics according to their educational needs, monitoring of the individual progress of the student; personification – the organization of the educational environment, including the electronic one.

The generalized model of blended learning at a higher education institution has been developed. The model is a variant of the consistent model of blended learning and is aimed at the in-depth study of educational materials and taking into account the individual preferences of students regarding the organization of their educational activities. The study of the results of the implementation of the generalized model of blended learning by conducting and analyzing the survey has made it possible to confirm the positive attitude of the majority of students towards the implementation of blended learning based on the proposed model. The further development of the research is the improvement of the proposed model due to the use of adaptive learning technologies, individualization and personalization of learning.

4) The functional learning model has been developed based on the combination of augmented and virtual reality technologies with adaptive learning systems. It is shown that the use of technologies of augmented and virtual reality in combination with means of adaptive learning has a great educational potential, as it allows teachers to take into account the psychotype of the personality, providing students with educational material in the most favourable form for assimilation, implementing elements of gamification. The model is presented in the graphic form. The main elements of the model are: a student; a teacher; a database of test tasks to determine the initial level, the current level and dominant type of thinking; a student model; a discipline profile; a database of educational materials (text, video, graphics, audio, simulators);

and an adapted course/module/lecture. The main operations that ensure the implementation of adaptive learning are: testing the student and determining the level of his success and psychotype (the leading channel for the perception of educational information); forming and updating the student model; analysis of knowledge gaps based on the student model and discipline profile; selection and arrangement of educational materials; formation of an adapted educational course.

5) According to the results of the analysis of psychological and pedagogical research on the problems of intensification of professional training of future specialists at higher education institutions, diagnosis and consideration of cognitive styles of higher education students in the process of education, it has been established that certain aspects of these phenomena are sufficiently well developed by scientists. Within the framework of cognitive psychology, the theory of cognitive styles has been developed, approaches to their classification have been defined, manifestations of cognitive styles of an individual in various situations have been characterized, and the connection between cognitive styles and the life and professional success of an individual has been characterized. The analysis of regulatory documents has shown that despite the achievements of pedagogical science and cognitive psychology, the problem of individualization and personalization of professional training of future specialists at higher education institutions based on the intensification and style approach has not been sufficiently studied.

Based on the analysis of domestic and foreign experience of intensification of professional training of future software engineers at higher education institutions, the following main directions have been determined: fundamentalization of the content of professional training and increasing the information saturation of educational material; use of appropriate forms, methods and teaching aids; implementation of accelerated educational programs. The first two approaches are widespread at higher education institutions of Ukraine, within which the main attention is paid to the content of education and, under the conditions of preserving the duration of education, its informational saturation and productivity are increased, and the third approach aimed

at reducing the duration of education is the most common at foreign higher education institutions.

Approaches to the interpretation of cognitive styles, their general characteristics, features of manifestation in the process of activity are given. Approaches to the classification of cognitive styles of personality are considered: the bipolarity and polypolarity-based approach; the model proposed by E. Kouls and H. Van den Broeck; basic and advanced models based on D. Kolb's learning cycle theory; the model based on a combination of ideas about the asymmetry of the cerebral hemispheres and the modality of information display; the VARK model based on four sensory modalities of perception of educational information by an individual.

6) Based on the results of the conceptualization and modeling of the adaptive system for the individualization and personalization of the professional training of future specialists under conditions of blended learning, a number of practical recommendations has been developed for the creation of adaptive educational content, the use of LMS Moodle for the organization of blended, personalized and adaptive learning at higher education institutions, the adaptation of electronic educational courses to a mobile format for blended learning.

The obtained results contribute to the adaptation of foreign experience in the use of adaptive learning systems, the creation of opportunities to meet individual educational requests of higher education students, the stimulation of new educational needs, the formation and consolidation of students' motivation for lifelong education.

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