

Modeling of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

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Abstract. The model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning is offered. It includes the contextual, pedagogical and instrumental subsystems. In the system, the adaptability is planned to be implemented through the adaptation of educational materials, monitoring, devices, face-to-face classes; individualization involves the study of students' individual features, support and assistance of student's individual syllabus, individualization of the learning process, development of student's individual features and formation of new characteristics according to student's educational needs, monitoring of student's individual progress; personalization involves the organization of the educational environment, including the electronic one.

Keywords: model of adaptive system, adaptive learning system, individualization, personalization, professional training, blended learning.

1 Introduction

Various aspects of the issue of improving the future specialists' training have been studied by many scientists and educators. As a result of pedagogical research, scientists [1–5] are increasingly inclined to believe that in the context of a great variety of educational content and individual preferences of students, the educational process can be

carried out through the introduction of adaptive learning systems in higher education institutions. Many scientists have devoted their research works to the modeling of such systems. In particular, M. Siadaty and F. Taghiyareh [3] proposed a pedagogically adaptive learning system based on learning styles. An adaptive learning system, focused on learning style and cognitive state, was designed by S. Chen and J. Zhang [6]. S. L. Huang and J. H. Shiu [7] developed a model of the user-centric adaptive learning system, which uses sequential pattern mining to construct adaptive learning paths based on users' collective intelligence and employs Item Response Theory (IRT) with collaborative voting approach to estimate learners' abilities for recommending adaptive materials. H. C. Huang, N. Y. Wang and F. M. Hsieh [20] introduced a model of the adaptive mobile learning system that provides learners with the content adapted to their knowledge levels, learning styles, and heterogeneous learning devices. However, the need for modeling and development of a system in which the adaptation technologies, approaches to individualization and personification of education for the purpose of future specialists' professional training in the conditions of blended learning in a higher education institution remains relevant.

2 Analysis of subject domains

In the process of modeling of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning (ASIPT), we relied on scientific works on the methodology of research and pedagogy [8–10] as well as on the modeling of pedagogical systems and environments [11–13]. We analyzed studies representing the development of adaptive systems (platforms) of learning in higher education institutions [14, 15].

In pedagogical science in order to accurately reflect the characteristic features of the phenomenon under study modeling is used, the result of which is a model of this phenomenon. The model is a project of the educational process, which will later be put into practice and its construction will allow choosing the most effective ways to achieve the aims of specialists' training [16]. Thus, the development of the ASIPT model facilitates the study and provides new knowledge about the original object (pedagogical process in the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning).

In this aspect, modeling of the pedagogical process in ASIPT is needed

in order to learn how to manage this process; to identify the best ways to manage it under certain organizational and pedagogical conditions, aims and criteria; to anticipate the direct and indirect consequences of realization of the set ways and forms of influence on the subject (students of higher education institution); to achieve the desirable outcomes (professional competence); to provide the process of future specialists' professional training in higher education institutions with technologies; to monitor the efficiency and quality of future specialists' professional training in higher education institutions.

As a methodological basis for the construction of ASIPT model, we used a polyparadigmatic approach [17], which involves the use of an open cluster of approaches to learning that do not interfere with each other and their integrated application has a synergistic effect. The leading role in this cluster is given to the systematic approach, which provides the basis for the subsystems (contextual, pedagogical, instrumental). The structures of these subsystems were identified. Let's describe each of the ASIPT subsystems in detail.

3 ASIPT subsystems

3.1 Contextual subsystem

The basis of ASIPT contextual subsystem is a general idea of the developed adaptive system, i.e. how the concept and idea of its development will be implemented. Given the fact that ASIPT model is used a blended learning environment, some aspects of the implementation of adaptation, individualization and personalization of learning in the process of distance and traditional (face-to-face) learning were identified (Fig. 1).

In ASIPT the adaptive learning is carried out by means of:

- 1) adaptation of educational materials (content of educational materials) — organization of algorithms for educational materials adaptation in a three-stage system: “introductory adaptation” (adaptation of the content of introductory educational materials of the discipline based on the initial level of students); “current adaptation” (adaptation of educational materials on the basis of current effective actions of students in the adaptive electronic environment (SDL)); “assessment-corrective adaptation” (adaptation of normative parameters of the level of materials acquisition taking into account the learning outcomes achieved by students) [18];
- 2) adaptation of assessment (testing) — specific ways are used to regulate the complexity and number of the proposed tasks, depending on

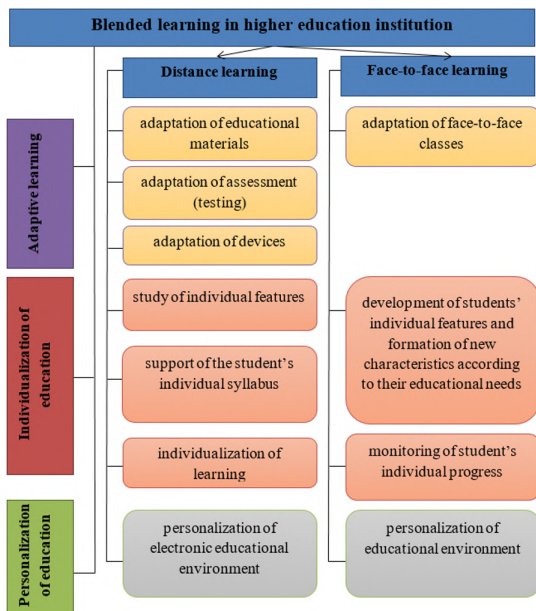


Fig. 1. ASIPT contextual subsystem

the students' results, including different testing options: pyramidal: everyone is given a task of medium level of complexity and then, depending on the result, everyone is given a more difficult task), flexible testing (starts with the level of complexity, chosen by the test taker, with a gradual approach to the real level of knowledge), stratified (conducted using a bank of tasks divided by levels of complexity: in case of the correct answer the next task is taken from the top level, in case of incorrect one — from the bottom level) [19];

- 3) adaptation of devices — adaptation of educational resources (portals, SDL, sites, etc.) to various computer devices (PCs, mobile phones, smartphones, tablets) [20];
- 4) adaptation of face-to-face classes — when having face-to-face classes new structures of courses are created; the variation of learning (content, forms, methods, means) and adaptation of educational process to students' individual features thanks to considerable increase in time allotted to the students' individual work take place; pair and group work; individual pace of students' work depending on the

level of knowledge, skills, innate abilities, and working capacity, etc.; creation of multilevel tasks for individual work; giving students a choice of the level of complexity of the tasks performed; wide use of generalizations and reference schemes in the learning process; management of educational process by means of the network plan; continuous monitoring of the individual work outcomes [21].

In ASIPT the individualization of learning gives an opportunity to individually plan content, pace and time of study using the list of educational resources. This plan is focused on the student's learning preferences and the opportunity to work according to the individual syllabus. In order to implement this option the following ways of individualization are planned in ASIPT:

- 1) study of students' individual features — at the beginning of learning a number of psychological and pedagogical activities are carried out; it provides the basis for the identification of student's individual learning path and for the analysis of the outcomes in order to take them into account in the learning process (for example, identification and proposal of the study time depending on the psychological features of the students);
- 2) support of the student's individual syllabus — considering the fact that individualization provides the organization of system of interaction between participants of educational process in which individual features of everyone [22] are most fully taken into account, the system has the option of the digitization of communication acts (their protocolling, algorithmization, timing, archiving) and monitoring of competencies, including educational and professional self-identification and self-presentation (professional portfolio) [23];
- 3) individualization of learning process — when implementing an individual educational route the students are provided with an opportunity to learn when it is convenient for them (morning, day time, evening) and at their own pace (faster, slower, flexibility of reporting time);
- 4) development of students' individual characteristic features and formation of new characteristics according to their educational — needs involve the implementation of “subject-subject” learning based on student's individualization, when such necessary qualities as independence, initiative, creativity, confidence, enthusiasm, research style, culture of search and work are forming and developing; these

qualities are necessary for the future specialist who will act in the new social conditions [22];

- 5) monitoring of student's individual progress — gradual compilation of the student's own professional portfolio, which reflects the outcomes achieved by him or her in the process of learning in a particular specialty without comparison with the achievements of other students.

In ASIPT personalization of learning facilitates a growing demand of users (learners) to meet their learning needs as well as their natural desire for greater productivity and comfort of mastering new competencies [24]. Teachers turn to personalization in order to intensify and increase the efficiency of the future specialists' training process.

Personalization of learning in ASIPT is carried out in two ways:

- 1) personalization of the electronic learning environment (PELE);
- 2) personalization of the learning environment (PLE).

PELE includes the creation of conditions for the consolidation of various Internet services, electronic resources and ICT tools in their relationships, through which the student builds his or her own learning process, including personalization of the SDL interface (depending on the results of individual features testing, the color frame of the student's personal page is offered). Access to learning turns into an access to resources and services and it allows students not only to use learning resources, but, most importantly, to create them. So, learning is transformed from a simple transfer of information and knowledge to their creation [25]. Personal e-learning environment is formed by means of a set of open educational resources, web services and software applications that have to perform certain tasks or functions in the educational process. It is described in more detail in the instrumental subsystem.

Personalization of the learning environment means providing students with conditions for having their own set of educational resources (teaching aids) in the laboratories of higher education institutions. It becomes possible under the condition of the creation of STEAM-laboratory in higher education institution. The laboratory space is organized in the format of Makerspace — a global format of creative spaces-workshops — as a place to brainstorm ideas, conduct experiments, study, put ideas into practice and improve student's new skills [26]. Teachers and students have the opportunity to come to the laboratory in order to use the special equipment available in it, which is expensive or quite specific in its characteristics. The space of the laboratory is specially planned for the purpose of appropriate and comfortable accommodation and work of its visitors, providing mobility,

flexibility and the ability to use technical aids when learning. Equipment of the STEAM-laboratory allows users to create optimal conditions for the realization of each student's potential in order to organize his or her personal learning environment in higher education institution.

3.2 Pedagogical subsystem

One of the main features of ASIPT is its structuring, which provides for the possibility of identifying its components, as any system has a structure that is a set of connections between parts of the whole [27]. Pedagogical subsystem of ASIPT model includes an understanding and presentation of aspects related to the process of future specialists' professional training. This subsystem, like the majority of pedagogical models of education which represent a unity of process and result, contains five components: target, theoretical-methodological, content, activistic, and resultative. We have added a creative component to the traditional structure of the pedagogical model, because in our opinion, learning systems should develop the creativity of future specialists, which contributes to more effective development of students' professional competencies (Fig. 2).

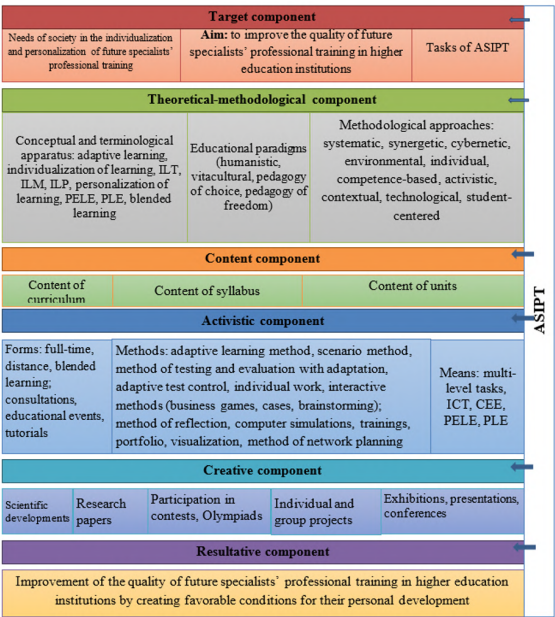


Fig. 2. Pedagogical subsystem of ASIPT

The target component identifies the needs of society in the individualization and personalization of future specialists' professional training; the aim is to improve the quality of future specialists' professional training in higher education institutions by creating favorable conditions for their personal development; tasks of ASIPT.

The theoretical-methodological component reveals the conceptual and terminological apparatus, educational paradigms and methodological approaches (systematic, synergetic, cybernetic, environmental, individual, competence-based, activist, contextual, technological, and student-centered) according to which ASIPT model is constructed.

The content component reflects the content of future specialists' professional training in the form of a syllabus, designed on the basis of the standard of higher education for Bachelors and Masters; content of courses, which is organized in accordance with the requirements of adaptive learning, including the distribution of didactic units in each discipline.

The activist component includes a system of forms, methods, means, organizational and pedagogical conditions that contribute to the improvement of the quality of professional education by developing the future specialists' competence necessary for successful future professional activity.

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

The resultative component shows the improvement of the quality of future specialists' professional training in higher education institutions by creating favorable conditions for their personal development.

All components are interconnected in ASIPT model.

3.3 Instrumental subsystem

To implement the adaptation, individualization and personalization of learning, this environment is created through the use of various tools: information and communication technologies, modern technical means of learning, hardware and software. These tools form the Instrumental subsystem of ASIPT model. Its schematic representation is shown in Fig. 3.

The basis for this subsystem is the distance learning system Moodle. It is not positioned by developers as an adaptive learning system. However, the growing popularity of adaptive learning technology has prompted Moodle developers and other programmers to improve the system. Therefore, to implement an adaptive approach, Moodle has developed appropriate

plug-ins. Among the analyzed plug-ins, we singled out Adaptive Quiz for adaptation of testing, IADLearning for adaptation of content and stack of plug-ins (Learner preferences, Learner adaptation, Navigation Web) for navigation adaptation [28].

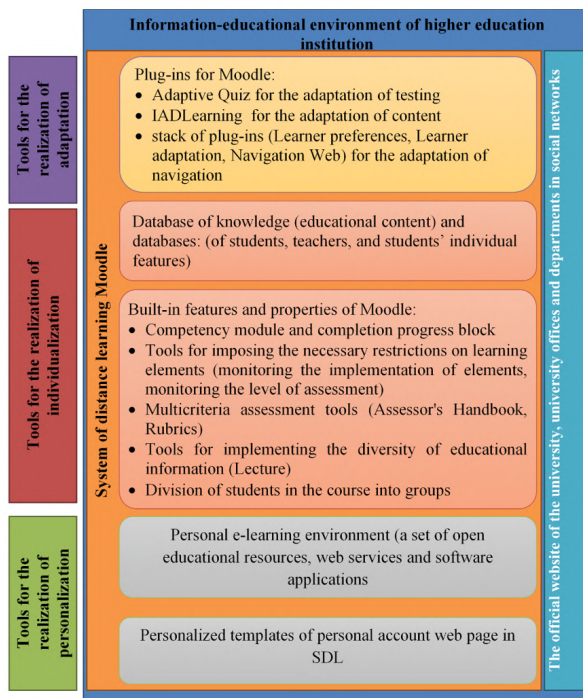


Fig. 3. Instrumental subsystem of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

To support the individualization of learning in SDL Moodle, there are the following advantages: creation of a course in SDL in the form of a modular structure; formation of modules with the accessibility of materials based on the results of studying previous modules and passing mid-course tests; creation of educational materials in SDL of a branched structure according to a pre-created pedagogical scenario (lecture with feedback); creation of resources with additional opportunities for material processing for students with insufficient level; creation of multilevel tests; creation and placement of individual tasks in the course of SDL [29].

The easiest way to individualize the course is to create mini-groups in SDL to optimize the path of their learning process. Creation of tasks and educational materials for groups depends on their initial level, educational needs and tasks oriented for the achievement of outcomes. It is also possible to add some additional materials that help to master the content of the course. In addition, in SDL Moodle it is convenient to support the development and implementation of project activities.

It is possible to integrate SDL Moodle with various information systems, which allows users to create and store an electronic portfolio. In the student's portfolio all the works submitted by him or her, grades and comments of the teacher, messages in the forum are saved. SDL Moodle offers the following tools for implementing an individual approach:

1. Tools for the formation of the learning route by imposing the necessary restrictions on the learning elements (tracking the execution (review), tracking the level of assessment).
2. Multicriteria assessment tools (Assessor's Handbook, Rubrics), which take into account the complexity of the material.
3. Tools that allow implementing a variety of educational information within the framework of a single distance course
4. Compilation of the profile of learning material representation for each group of students.

Individualization of the learning process using Moodle can be expanded through the use of mobile learning technologies [30]. This is the way how mobile learning can be adopted and developed as a supplementary line in higher education institutions [31]. It is achieved through various mobile technologies. In particular, for the implementation of individual learning, in addition to access to Moodle via a mobile phone browser, there is a mobile application Moodle in the App Store and Google Play. The SDL Moodle mobile application has a user-friendly interface and full functionality for students learning distantly.

For the organization of a personal electronic learning environment (PELE) it is advisable to use appropriate tools. It should be noted that some tools from Internet service providers can be used as examples of tools in PELE. Based on our expert experience of long-term work with ICT we have outlined only some examples (Table 1).

Table 1. Tools for organizing a personal electronic learning environment in ASIPT

| Tasks, function of tools | Type of tools | Sample tools |
|--|---|---|
| Organization of a single entry point | Educational portal | Official site of higher education institution |
| Google Apps for Education | | |
| Organization of learning | System of learning management | Moodle, Google Classroom |
| Publication of educational materials | Services for e-courses creation | Edmodo, Eliademy |
| | Video hosting | YouTube |
| | Services of online presentations | Prezi |
| | Google Slides | |
| | Photo hosting | Google Photos, Imgbb |
| | Services for materials publication | Google Docs |
| Development of practical skills | Virtual stimulators | Codecademy, GeoGebra, STAR, Classmaster, PhET |
| Cooperation | Services of joint work with documents | Google Docs |
| | Online boards | Twiddla, Miro, IDroo |
| | Online mind maps | MindMeister |
| | Services for the organization of teamwork | Trello, Asana |
| | Services for project management | CRM Bitrix24 Wrike, Basecamp |
| Communication | Messengers | Viber, Telegram |
| | Applications for group calls | Discord |
| | Video conference services | Skype, Google Meet, Zoom |
| Systematization and storing data and information | Cloud storage | Google Drive, Dropbox |
| | Notes storage services | Evernote, Netboard |
| | Services for collecting | Pinterest |

Continuation of tables 1

| Tasks, function of tools | Type of tools | Sample tools |
|--|--------------------------------|--|
| | and systematizing information | |
| Presentation of learning outcomes | Services for sites development | Google Site, Wordpress.com |
| | Portfolio services | Behance.net, Clippings.me |
| Search for educational resources | Search services | Google Search, Google Scholar, Google Maps |
| Information about the events in the university | Social networking pages | Facebook, Instagram, Twitter, TikTok, LinkedIn |

4 Model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

Three presented ASIPT subsystems can be generalized in one ASIPT model (Fig. 4).

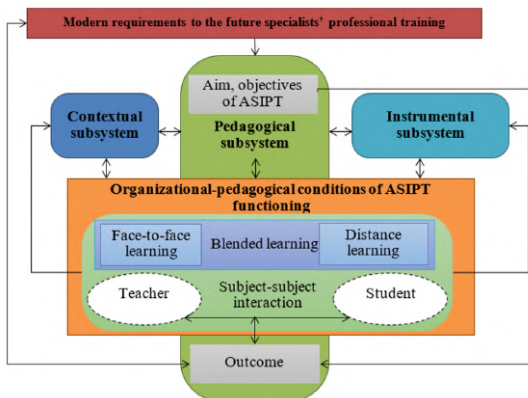


Fig. 4. Model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

The developed model of ASIPT which includes three subsystems (contextual, pedagogical, instrumental) takes into account modern requirements to future specialists' professional training which agree with the aim and outcome of its implementation. All subsystems are interconnected and are determined by the organizational and pedagogical conditions of ASIPT, the leading of which are the conditions of blended learning and subject-subject interaction between the main participants of the educational process (teacher, student).

5 Conclusion

In the model of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning, adaptability is planned to be realized through the adaptation of educational materials (content of learning), assessment (testing), devices, face-to-face classes; individualization includes the study of students' individual features, support and assistance of student's individual syllabus, individualization of the learning process, development of student's individual features and formation of new characteristics according to student's educational needs, monitoring of student's individual progress; personification involves the organization of learning environment, including electronic one. A further perspective of the research is the development of a working prototype of an adaptive system based on the stack of educational and information and communication technologies implemented in the structure of higher education institutions.

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Моделювання адаптивної системи індивідуалізації та персоналізації професійної підготовки майбутніх спеціалістів в умовах змішаного навчання

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Анотація. Запропоновано модель адаптивної системи індивідуалізації та персоналізації професійної підготовки майбутніх спеціалістів в умовах змішаного навчання. Він включає контекстну, педагогічну й інструментальну підсистеми. У системі адаптивність планується реалізувати через адаптацію навчальних матеріалів, моніторингу, приладів, очних занять. Індивідуалізація передбачає вивчення індивідуальних особливостей учнів, підтримку та сприяння індивідуальному навчальному плану учня, індивідуалізацію процесу навчання, розвиток індивідуальних особливостей і формування нових характеристик відповідно до його освітніх потреб, а також моніторинг індивідуальної успішності; персоналізація ґрунтується на організації освітнього середовища, зокрема електронного.

Ключові слова: модель адаптивної системи, адаптивна система навчання, індивідуалізація, персоналізація, професійне навчання, змішане навчання.