The state of the art and perspectives of using adaptive cloud-based learning systems in higher education pedagogical institutions (the scope of Ukraine)

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Abstract. The article deals with the problems of using adaptive cloud-based learning systems (ACLS) in the modern high-tech educational environment and expanding access to them as tools of educational and research activity at higher education pedagogical institutions in Ukraine. The conceptual apparatus of cloud-based adaptive learning systems application and design is considered; their main characteristics are revealed; the ways of their pedagogical application are described. The experience of Institute of Information Technologies and Learning Tools of NAES of Ukraine on designing and applying of the cloud-based learning and research environment is outlined. The results of the survey of 31 higher education pedagogical institutions on using ACLS are presented. It is established that in the near future ACLS will become the driving force behind the development of new pedagogy, new strategies for personalizing education, and expanding opportunities for active learning.

Keywords: cloud technology, learning-scientific environment, higher education pedagogical institution, adaptive cloud oriented learning system (ACLS).

1 Introduction

Modernization of teaching and learning in higher education institutions bringing it in line with the current achievements of scientific and technological progress is one of the priority problems of Ukrainian pedagogical research. One of the main conditions for the modernization of education, improving the quality of teaching and research staff training is the use of innovative technologies, in particular, the introduction of adaptive learning systems in educational institutions.

Adaptive learning systems attracted the interest of researchers in the field of ICT in education at almost all stages of development of this industry. It is always the goal of those who develop and implement computer-centric systems to create tools that would most fully meet educational needs. The cloud computing approach gives the new insights into the field of adaptive learning as artificial intelligence approaches and advanced networks tools merge to create the new trend [1]. The adaptive cloud-based

learning systems become the new stage of adaptive systems development that have a great potential and significant prospects for use in educational institutions.

The purpose of the article is to determine the essence of adaptive cloud-based learning systems, the state of the art of their use in educational institutions of Ukraine, outline the prospects for their development and implementation.

2 Review

With the development of cloud computing the possibilities for individualization and adaptability in educational systems have increased significantly. Despite the fact that modern adaptive systems are still in the process of experimental study, they are gradually developing and implemented in educational practice in different countries [13] at different levels of education [11]. These systems are aimed at ensuring the differentiation and personalization of training at a higher level compared with previous generations. The principles of their work concern the dynamic adaptation to individual needs of the subject of the training course, which are conditioned by the abilities, knowledge and skills of the learner. By "tracking" the process of student's knowledge acquiring a system with a high degree of accuracy builds the educational path, sequentially "moving" from one unit to the next until as the planned results are achieved [1].

Problems of designing and implementing adaptive learning systems in Ukraine including cloud-based are at the initial stage of development. So Pavlo I. Fedoruk highlights the methodology of organizing the process of individualized learning using the Web-based adaptive system of distance learning and knowledge control [3]. The peculiarities of the creation of a cloud-based learning and research environment of a higher education institution were considered by Valerii Yu. Bykov and Mariya P. Shyshkina [2]. Serhii M. Pryima analyzed peculiarities of intellectual adaptive learning systems of open adult education in accordance with the recommended didactic-educational strategy and methodology of analysis and empirical data Web Mining as the technology for the use of valuable knowledge [13].

First of all, scholars believe that adaptability is important in distance learning, as the distance learning system should be oriented towards a large number of users with different levels of knowledge.

So, Pavlo I. Fedoruk [4] considers the problem of personalization of distance learning, which, according to the author, can be achieved using adaptive and intelligent technologies. According to Pavlo I. Fedoruk, in the educational process, more attention should be paid to navigation systems; to make more efficient use of Internet resources, electronic libraries and repositories [5]. The researcher explored the problem of designing intelligent learning systems and noted that such systems should have an intuitive interface, so that the teacher could not only work with already prepared training material, but also independently modify, update and create their own developments. In the framework of the research, Fedoruk argued that through the use of adaptive and intellectual technologies, the educational system receives the opportunity to take into account the student's personal abilities, his prior knowledge,

and ability [5]. The researcher discovered that none of the distance learning systems he considered, none of them was adaptive to interact with student groups, that is, they did not take into account the individual characteristics of each student and teacher training.

Elena V. Kasyanova, in 2006, researched adaptive hypermedia systems [9], which, in her opinion, greatly enhance the possibilities of educational systems in general. In addition, according to Kasyanova's research, all adaptive hypermedia systems can be united into one class, the components of which can include hypertext and hypermedia systems. Due to this, for each user, his workplace will be adapted with the individual tools and settings of various aspects of the system itself (without affecting the work of other users).

Theoretical and practical principles of the development and use of adaptive learning systems are actively studied by foreign experts. Peter Brusilovsky and Christoph Peylo conducted a comparative analysis of intellectual and adaptive learning systems, identified the prospects for the development of such systems on the basis of the Internet [1].

The thorough analysis of the concept of an adaptive learning system and its model design is presented in the works of Lou Pugliese [14; 15].

The experience of developing an adaptive open-source online course based on cloud-based Amazon Web Services architecture is presented in the paper [19].

Researchers [21] developed an adaptive learning system with two sources of personalization. Their research is based on two main sources of information about personalization such as behavior in learning and personal learning style.

If to turn to the theory of adaptive systems, then the task is reduced to the construction of a regulator, which will affect a certain object / subject and in time will ensure (under all conditions) the achievement of the goal. A system consisting of object / subject parameters and the specified controller will be called adaptive [7]. If you return to the research topic, then in this case the cloud-based system will act as the regulator.

In turn, according to the study by Vladimir G. Sragovich [20], the adaptability of the control algorithm means that the goal is provided on the whole class (objects / subjects and functional connections), besides, it remains unknown to the end, which the process itself is being managed. In the presence of a strategy it becomes possible to evaluate the characteristics of the process over which the control takes place. However, Sragovich emphasizes that it is not necessary to evaluate and control the object simultaneously. That is, the adaptive system changes its algorithm (or its structure) automatically, which means achieving the goal in any conditions.

Thus, modern adaptive learning technologies are specialized software or services that adapt to the needs of students. These tools are able to synchronize with the learning process and, based on the technology of machine learning [17; 18], can adapt to the progress of each student and independently adjust the training content in real time.

Any adaptive learning system shapes the model and profile of each user. The user profile stores personal user information such as scientific (training) benefits, training mode and user knowledge. The model is based on a profile research. Jelena Nakic, Andrina Granic and Vlado Glavinic [10] studied the characteristics needed to build a user model for adaptive learning systems. According to the research, as the sources of adaptation, selected individual characteristics of users. The result of the study can be

considered a list of 17 characteristics that are considered sources of adaptation (age, gender, cognitive abilities, such as speed of processing, long-term memory, spatial ability and others, metacognitive ability, personality, anxiety, emotional and affective states, cognitive styles, learning styles, experience, background knowledge, motivation, expectations). According to the results, the adaptation of educational systems increases when they are adapted to one or more of the listed characteristics of the user.

The development of cloud computing, the growth of complex implementations in the cloud, has increased the requirements for the internal and interdomain network. However, it should be recognized that network performance is one of the key issues when implementing multi-cloud solutions. This leads to the fact that network management is considered as a major problem; it is an integral part needed to provide integrated security and application performance [6].

This leads to the fact that cloud-based network infrastructure must be extremely flexible and responsive to changes in queries dynamically as a complex workflow is implemented with the use of several cloud-based applications. To achieve this goal, the network must be fully automated, which leads not only to reduce the cost of supplying the new infrastructure, but, most importantly, allows you to independently provide yourself. Self-sufficiency, on the other hand, means that the network becomes service-oriented, provides automated control with adaptive levels of security and control. All this leads to improved user experience when the API interface becomes a flexible programming environment that works concordantly and meets the requirements of the cloud application level. Thus, in the process of debugging operations and managing the general cloud-oriented system discussed in the previous section, network deployment should be included. The main objectives of the network deployment process are to ensure the dynamic behavior of the network, which can be fully consistent with the client's requirements through self-adaptation and increased flexibility [6].

A group of scholars to better adapt to a wide range of uses provided by community of users. Davide Salomoni, Isabel Campos, Luciano Gaido et al. [16] decided to take a different approach from many of the more used PaaS: the solution is based on the concept of an orchestrated complex cluster of services and the ability to automate the actions needed to implement cases of use. This approach was really successful as it enabled the implementation of outdated programs and did not depend on the language on which the program was built.

Given that the practical experience of applying adaptive learning systems, both in Ukraine and in the world in general is rather insignificant consideration of the conceptual foundations of this technology is important in order to avoid ambiguity of interpretation and approaches to understanding its essence. The features and perspectives of the use of adaptive cloud-based systems in higher education pedagogical institutions, in the training of pre-service and in-service teachers, who are the main driving force of the introduction of innovations into general secondary education are not considered enough.

3 Results

3.1 Adaptive learning systems: the essence of the concept

Ability to adapt is one of the critical indicators that determine the human intellect and behaviour. People did not disappear just because they had a special ability to be adapted to everything that was happening in the surrounding environment. What should be the essence of a system to be adapted to such a complex entity as the person? To do this the model of a person namely a student, a teacher or a learner with a large number of parameters should be provided. The system should be configured in accordance to these parameters, flexibly respond to changes in parameters, with the setting going on automatically, without human intervention, then the system is adaptive to the full extent.

For this configuration the system should be provided with the algorithms for customization, which are usually created with the use of artificial intelligence methods. The flexibility of the system in terms of artificial intelligence can be greatly enhanced by the use of cloud computing approach. The cloud-based system is very flexible by its nature. The necessary computational resources such as memory, processing power, bandwidth network, etc. can be provided and discharged as needed, scaling takes place very quickly. In addition, this system has the ability to be adapted to tasks that can be added or modified as needed. So the adaptation may be provided also by functionality. Thus the cloud-based technologies have additional opportunities for a wider range of adaptation due to the much higher flexibility of their software and hardware and their characteristics.

Thus by *the adaptive cloud-based learning system* the cloud-based system that has the property to be adjusted automatically by its parameters to the different individual characteristics and educational needs of the learning process participants is meant.

In order to implement the computer-procedural functions of this system, a virtualized infrastructure (corporate or hybrid) should be purposefully created.

Among the advantages of the ALS are the following:

- automation of evaluation and forecasting, which greatly enhances the efficiency of these processes;
- the ability to be adapted to each student, regardless of the starting level of knowledge, abilities, peculiarities of psycho-physical development, etc., unlike the traditional system in which the student should be adapted to the general standards;
- adjustment of the degree of complexity of educational content, which contributes to a more efficient, consistent course of study;
- the possibility of constant evaluation, tracking the student's academic progress and adjusting it if necessary;
- the possibility of obtaining data not only about the educational progress of each student but also his individual needs;
- the possibility for the student to carry out self-analysis, track their own educational route, progress in the learning process through the receipt of feedback (feedbacks) from the system in real time;

- the encouragement of students to self-development and the implementation of an individual educational trajectory, regardless of the teacher, with the help of automated feedback loops;
- the possibility of reducing the routine load on teachers, releasing time for professional development, etc.,
- the possibility of continuous improvement of training courses on the basis of in-depth analysis of educational progress, peculiarities of the individual trajectory passing by each student which contributes to the improvement of the quality of educational activity of the institution as a whole.

ALS usually require architecture that integrates key functions of modules (training content), assessment and competencies, which together should provide support for a personified educational environment. As indicated in [14], ALS, at least, should contain the list of methods that provide:

1. The training modules (content) to be completed;
2. Several evaluation systems that track and assess students ' learning outcomes;
3. Methods for coordinating the demonstration of learning content to individual students in a dynamic and personalized way.
4. The analysis of the source base allowing the selection of a number of indicators that determine whether the learning system is adaptive.

So, consider the system of learning to be adaptive if it:

1. Can be adapted to different learning styles (for example, different pace).
2. Contains statistically accurate cognitive models that allow to determine and verify the reliability of the achieved competence level of students.
3. The adaptive sequence can be correctly implemented for the accurate and continuous collection of data in real time for the student's progress and the use of these data for the automatic correction of the educational route.
4. Contains a functions for adaptive evaluation.
5. It can accurately identify corrections and corrective actions through adaptive evaluation (both on the basis of norms and on the basis of criteria).
6. It is possible to synchronously measure critical components of the knowledge (how successful the student has mastered the content) and behavioral (how much time a student was actively involved in the learning process).
7. It can develop complex competencies characteristics that index the learning outcomes.

With regard to the cloud-based approach we also need to consider the cloud-based learning platform providing the ICT infrastructure for the adaptive learning system implementation. The learning platform is considered as the set of the cloud-based tools to support different learning and research activities. Within the unite platform a lot of different tools may be integrated providing more opportunities to realize adaptive learning.

3.2 State of the art of using adaptive learning systems in higher education pedagogical institutions of Ukraine

In order to find out which training support systems are used in educational institutions of Ukraine, and whether there are adaptive systems, we conducted a survey. Interviews were held with the representatives of 16 pedagogical universities and 15 institutes of postgraduate pedagogical education of Ukraine (31 institutions – 31 respondents) competent in the issues of which educational systems are used in the institutions where they work (technical departments, distance learning departments, specialists in issues of informatization of the institution, etc.), in the fall of 2018. It was established that currently none of the institutions surveyed uses ALS. The results of the survey are rendered in Fig. 1-3.

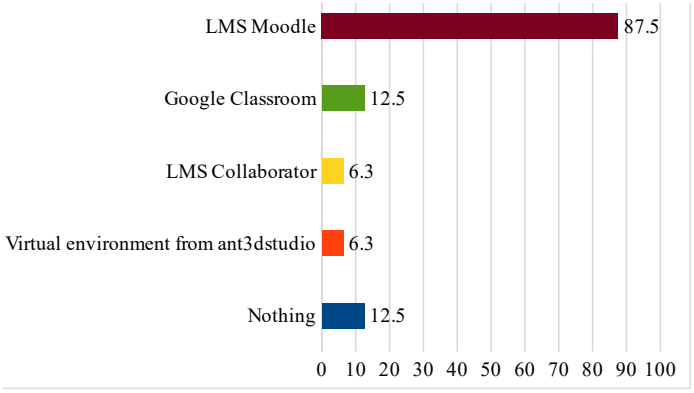

Fig. 1. The systems of training support used in pedagogical universities of Ukraine

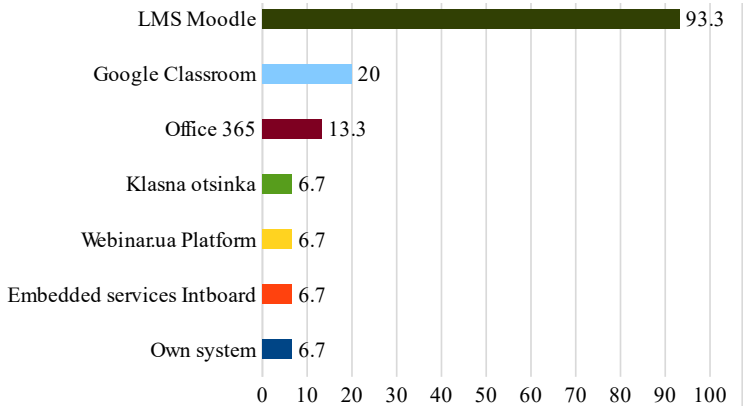

Fig. 2. The systems of training support used in institutions of postgraduate pedagogical education of Ukraine

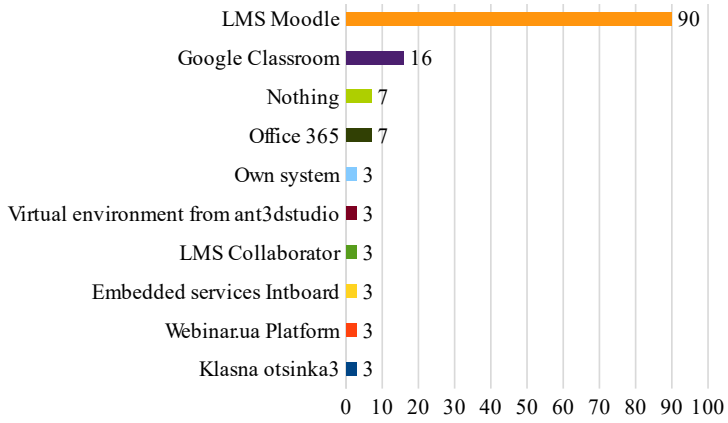

Fig. 3. The systems of training support used in institutions of pedagogical education of Ukraine – pedagogical universities and institutes of postgraduate pedagogical education (consolidated data)

As you can see, the most common is the Moodle Learning Management System (LMS Moodle). Despite the wide range of functionalities and the range of benefits provided by this system, it is, however, not adaptive, as well as the rest of the tools currently used in institutions of pedagogical education in Ukraine.

On the basis of a conducted survey it can be concluded that the cloud-based platforms being the necessary condition to provide ACLS are used only in 16 % of institutions.

So, we believe that scientifically and pedagogically grounded introduction of such systems will contribute to the learning environment development that the will become more open, personalized, will enable access to high-quality educational content for all subjects of learning with regard to their individual characteristics.

Note that today the ALS are only at the beginning of active development and progressive implementation. Even in the technologically developed countries of the world such systems have become widely distributed undergoing experimental testing. According to [8], in the next few years, the ALS will be the driving force behind the development of new pedagogy, new strategies for personalization of education, and the expansion of active learning opportunities.

4 Conclusions and discussion

The analysis and assessment of the state of the art of using adaptive cloud-based systems in the domestic educational space has shown that the adaptability is largely not realized; the use of cloud-based services is not complex, conditioned by learning needs and subordinated to pedagogical goals of teachers training.

In 2018 the Institute of Information Technologies and Learning Tools of NAES of Ukraine became one of the partners of V4+ Academic Research Consortium that would

address regional issues related to EU ICT research priorities. The focus will be on the networking of the V4+ partners in order to integrate their research expertise, perform partner search and benchmark these issues using the virtual technological platform. The important part of the project is to explore the use of the cloud-based platform to integrate and deploy different types of learning and research services such as educational robots, language technologies and databases [12].

Despite numerous partial studies of specific issues in adaptive learning systems and cloud-based systems, the design and use of adaptive cloud-based systems remains relevant and current. ALS are still developing, gradually gaining momentum in developed countries of the world. The basis of the functioning of such systems is the competence approach, focusing on individual progress.

Because these systems require computation of a very high order, analyzing enormous amounts of data in real time, the scalability of the system can be considered from two points: how to effectively program these systems and how to prepare such an architecture to provide the processing, loading, distribution of these data. In view of this the relevant and perspective point is to study the principles and approaches of designing the ALS on the basis of cloud platforms, as well as developing methods for their use in the professional training of teachers as the main driving force of the introduction of innovation into general secondary education.

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