The Review of the Adaptive Learning Systems for the Formation of Individual Educational Trajectory

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Abstract. The article is devoted to the review of the adaptive learning systems. We considered the modern state and relevance of usage of the adaptive learning systems to be a useful tool of the formation of individual educational trajectory for achieving the highest level of intellectual development according to the natural abilities and inclination with the help of formation of individual trajectory of education, the usage of adaptive tests for monitoring of the quality of acquired knowledge, the formation of complicated model of the knowledge assessment, building of the complicated model of the subject of education, in particular considering the social-emotional characteristics. The existing classification of the adaptive learning systems was researched. We provide the comparative analysis of relevant adaptive learning systems according to the sphere of usage, the type of adaptive learning, the functional purpose, the integration with the existing Learning Management Systems, the appliance of modern technologies of generation and discernment of natural language and courseware features, ratings are based on CWiC Framework for Digital Learning. We conducted the research of the geography of usage of the systems by the institutions of higher education. We describe the perspectives of effective usage of adaptive systems of learning for the implementation and support of new strategies of learning and teaching and improvement of results of studies.

Keywords: Adaptive Learning Systems, Individual Approach in Education, Individual Trajectory of Education.

1 Introduction

1.1 Problem statement

In the context of the modern progressive development of informational technologies, the education is experiencing global changes in the direction of rise and improvement

of the quality of educational services and as the result the increase of intellectual potential of the society. Therefore, the modern education should be aimed at the interdisciplinary and transdisciplinary as the result of implementation of the competent and student-centered approaches, that is realized by the implementation of individual educational trajectories in the educational process. In view of the labor intensity of the process of building of individual educational trajectory that is aimed at the achievement of the highest level of intellectual development according to the natural abilities and inclinations of each subject, the reevaluation of ideas of adaptive learning on the systems of machine learning appears to be appropriate. The expansion and diversification of educational services at the expense of usage of intelligence and adaptive systems of learning is achieved with the help of the development of adaptive tests for monitoring of the quality of acquired knowledge, the formation of complicated model of the knowledge assessment, building of the complicated model of the subject of education, in particular taking into account social-emotional characteristics. The result of the effectiveness of usage of the adaptive learning systems in the educational process is the reduction of the amount of students, who decided to stop studies.

1.2   Problem state of the art

The usage of adaptive opportunities of the modern technologies in education is reviewed by great amount of researches and is presented at the large-scale profile scientific conferences. The issues of application of the intelligence systems in education are considered in following range of the researches [1; 2; 3]. The principles of adaptive learning are considered in number of studies: [4; 5]. To the issue of application of the systems on the base of the adaptive hypermedia in educational process are devoted such works as [6; 7; 8]. The thorough study of the systems of adaptive testing is conducted in the framework of research [9], and the issue of application of the computer neural network technologies as the tool of individualization of education was researched in works [10; 11; 12]. The designing of intelligence system for the analysis of educational qualifications frameworks is considered in [13; 14]. Realities and prospects of distance learning in different aspects is considered in [15; 16; 17; 18; 19; 20]. However, the problem of application of the adaptive learning systems at the domestic institutions of higher education did not find sufficient display.

  The aim of article is the analysis of functional opportunities of adaptive systems for the formation of individual trajectory of education.

2   The results of research

2.1   The main information regarding the technologies of adaptive learning

In the framework of the conducted educational reform takes place the quality transition of the system of modern education to mainly competence approach in education, built on the paradigm, which provides for the formation of individual educational trajectory for every student. In particular, during the round table on the topic "The educational politics in the terms of the informational society", held on the 24th of May, 2016 by the

Committee on Science and Education and the Committee on Information and Communication together with the Association of Information Technology Enterprises of Ukraine, particular attention was emphasized on the fact that the information and communication technologies allow to carry out the individual approach and development of every personality according to the individual styles of studies, using their individual trajectories of education – thus, the talents of every personality can be developed, and not only teach everyone in the same way. Also, the Law "On Education" [21], the addition to which was expanded by such notions as "individual educational trajectory", "individual program of development" and "individual curriculum", has acquired changes in the direction of the assistance of formation of individualized education. The adaptive learning is the technological pedagogical system of forms and methods, that facilitates the effective individual education, and the combination of this technology with the opportunities of modern information communication technologies has the considerable potential for education. The important role in the implementation of new educational paradigm plays the technology of AL, which relies on the achievement of modern information communication technologies.

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 assessment 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 [22, 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.

The research of peculiarities of usage of the ALS, the territorial characteristics of implementation in the educational process are important due to the fact that the application of the adaptive learning systems has a lot of advantages.

2.2   The existing adaptive learning systems and their classification

For the conduction of research of the available adaptive learning systems let's consider the existing types, relying on the classification that is provided in the researches [23,

pp. 14-18]; [24]; [25, p. 130], we will describe several types of the adaptive systems of learning.

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.

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.

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.

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.

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.

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).

While conducting of the analysis of the available ALS, we detected a few more types. *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. *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. *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. *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 conducted review of the existing adaptive learning systems we will systematize in the Table 1.

Table 1. The existing adaptive learning systems.

System	Web-site	Type	Developed by	Year of dev.	Charges	System Cloud	Mobile	Local
Course Arc	coursearc.com	ALP	Bethany Meyer, Katie 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/revel/	ALP	Pearson	2012/2020	Pay	+	+	−
Junction	junctioneducation.com	ALP	Junction education	2013/2019	Pay	+	+	−
Smartwork5	wwnorton.com/smartwork5	AET	W. W. Norton	2012/2020	Pay	+	−	−
MindTap	cengage.com/mindtap	LODE	Cengage Learning	2009/2020	Pay	+	+	+
InQuizitive	wwnorton.com/inquizitive	ALP	W. W. Norton	2000/2020	Free/Pay	+	−	−
BNED	bnedcourseware.com	ITS	Barnes & Noble Education	2015/2019	Demo/Pay	+	−	−
Smart-Sparrow	smartsparrow.com	ALP	University of New South Wales	2010/2018	Trial/Pay	+	+	−
Author	muzzylane.com	ITS	Muzzy Lane Software	2002/2020	Free/Pay	+	+	−
OLI	oli.cmu.edu	ALP	William & Flora Hewlett Found.; Carnegie Mellon	2001/2019	Free/Pay	+	+	−
Fishtree	fishtree.com	ALP	Fishtree	2012/2020	Free/Pay	+	+	−
MindEdge	mindedge.com	AEHS	MindEdge, Inc	1998/2020	Pay	+	+	−
Learning Objects	learningobjects.com	ALP	Washington, DC	2003/2020	Pay	+	+	−
Straighter-line HE	straighterline.com	ITS	Straighterline, Inc.	2008/2020	Pay	+	+	−

System		Web-site	Type	Developed by	Year of dev.	Charges	System		
							Cloud	Mobile	Local
	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	AE HS	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	+	−	−
	SoftChalk Create	softchalk.com	ITS	SoftChalk LLC	2002/2020	Pay	+	+	−
	NWEA	nwea.org	ALP	Northwest Evaluation Association	1973/2019	Free/Pay	+	+	−
	iTutorSoft	itutorsoft.com	AD LP	Greater Washington DC (Vlad Goodkovsky)	2012/2019	Free	+	+	−
	GIFT	gifttutoring.org	ITS	U.S. Army Research Laboratory	2009/2019	Free	+	+	+

One of the biggest and functional adaptive systems nowadays is CogBooks. The courses, placed on the platform, are developed together with the scientists of universities. 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. The visualization of territorial distribution is demonstrated on the Fig. 1.

Fig. 1. The territorial distribution of the adaptive learning systems

According to the analysis of the distribution of the adaptive learning systems we make the conclusion that the systems acquired the widest spread on the territory of The United States of America. The adaptive learning systems acquired the big distribution in Canada (Revel, Möbius and Brightspace LeaP). In Great Britain at University of Birmingham Möbius is applied in studies, Muzzy Lane Author is used at The University of Chicago Center in Delhi. Smart Sparrow is used in Australia at the University of New South Wales (UNSW Sydney) and at St. Petersburg University. Reviewing the system that was developed by Vlad Goodkovsky iTutorSoft (CLARITY) let's remark its usage at South-Ukrainian Nuclear Power Plant; Novo-Voronezh Nuclear Power Plant; US NAVY; Kursk Nuclear Power Plant; University of Virginia; Carney Inc and ScreenMentor Inc.

2.3 The results of review of the functional opportunities of the ALS

The type of every system was determined for better understanding of the functional opportunities of the systems of popular ALS. For determination of the type of adaptive system of learning we were guided by the following abbreviations: 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). Also by functional opportunities, which were the subject of research, we determined the usage of Natural language technologies (NLT), in particular the availability of technologies Natural language processing (NLP)

and Natural language understanding (NLU). To the significant factors, according to which the adaptive systems of learning were analyzed, also we reviewed the single-point adaptation (Sp) та the continuous (C) adaptation. The analysis of the functional opportunities of the adaptive learning systems is provided in the Table 2.

Table 2. The review of the functional opportunities of the adaptive learning systems.

System	competency–based	Courseware Features				LMS Integration						NLT		Types of AL			
		Course Builder	Course Complete	Pre-made Course	Supplemental	Blackboard	Canvas	Brightspace by D2L	Moodle	Sakai	Schoology	NLG	NLP	single-point / continuous	adaptive learning	adaptive testing	complex valuation
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	+	+	+
OLI	–	–	+	+	+	+	+	+	+	–	+	–	–	C	+	+	+
Fishtree	–	+	+	–	+	+	+	+	+	+	+	–	+	C	+	+	+
MindEdge	–	–	–	–	–	–	–	–	–	–	–	+	+	Sp	+	+	+
Learning Objects	+	+	+	+	+	+	+	+	+	–	–	+	–	C	+	+	–
Straighterline	+	–	+	+	–	+	+	+	+	+	+	–	–	C	+	+	–
Knewton	+	–	+	+	+	+	+	+	+	+	+	+	+	C	+	+	+
Web Assign	–	–	+	–	–	+	+	+	+	+	–	–	–	C	+	+	–
Omega Notes	–	+	–	–	–	–	–	–	–	–	–	–	–	C	+	–	–
ModCourse	–	+	+	–	–	+	+	–	+	–	–	–	–	C	+	+	+
panOpen	+	+	+	+	+	+	+	–	–	–	–	–	–	C	+	+	+
Drillster	+	+	–	+	+	–	–	–	+	–	–	+	+	C	+	+	–
CogBooks	–	+	+	+	–	+	+	+	+	+	+	–	+	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 [26] and systematize in the Table 3.

Table 3. The opportunities of the adaptive learning systems according to Ratings company self-assessment, guided by the CWiC Framework.

System	Courseware Features (Ratings by the CWiC Framework)					
	Adaptivity	Customization	Learner Autonomy	Socio-Emotional	Assessment	Collaboration
CourseArc	Low	High	Low	Low	Low	Low
Realizeit	High	High	Medium	Medium	High	High
Möbius	High	High	Low	Low	High	Low
Junction	High	High	High	Medium	High	High
Smartwork5	Medium	High	Low	Low	High	Low
InQuizitive	Low	High	Low	High	Medium	Low
BNED	Low	High	Low	Low	Medium	Medium
Smart Sparrow	High	High	High	High	High	Medium
Author	Medium	High	High	High	High	High
OLI	High	High	Low	High	High	Medium
Straighterline HE	Low	Low	Medium	Low	High	Low
Knewton	High	High	Low	Low	High	Medium
WebAssign	Low	High	High	Low	Medium	Medium
CogBooks	Medium	High	Low	Low	High	High

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), each of which was ranked in accordance to the scale low, medium and high. According to the results of the research let's summarize that the adaptive learning systems have the wide functional in the building of individual educational trajectories that adjust to the educational needs of every person, thereby realizing the personified studies. The main reason of the creation and application of such systems is the fact that all people perceive information differently.

For some it is enough to read the paragraph once and for some a week of cramming is not enough. Using the system of adaptive learning it is possible to build the individual trajectory of education, what will adjust to the educational problems of every pupil, providing the best variant of the educational trajectory that realizes the personified individualized study. For example, the building of the individual trajectory of education in Knewton system reacts to the results of a separate student and his actions in the system in real time. The illustration of the principle of building of the individual trajectory is provided directly in "Knewton Adaptive Learning. Building the world's most powerful education recommendation engine" [27, pp. 6-7]. Such approach enlarges the probability of the fact that a student will receive the right educational content at the necessary moment and will achieve the set aims. For example, if a student copes poorly with the definite set of questions, then Knewton can assume what topics, raised in this list of questions, turned out to be incomprehensible and offer him the content that will help to raise the level of understanding of precisely these topics.

3   Conclusion

According to the results of research we can make the conclusion that nowadays the adaptive learning systems only start the active development and gradual implementation. Even in the developed countries of the world such systems did not acquire the significant distribution and undergo the experimental approbation. Such systems, in comparison with the elaborations of previous generations, configure better and faster in the process of work, are characterized by the flexibility and openness to modifications that eventually allows ensuring of the individualization, personalization, personal-oriented approach in education. The algorithm of the adaptive learning systems assesses the results of every pupil in the mode of real time and depending on this adjusts its content, tempo, etc. The competence approach, orientation to the individual progress is laid in the basis of the functioning of such systems. Bearing in mind the above mentioned, we consider the studies of the theoretical principles of designing and implementation of the adaptive learning systems in the educational process, and also the development of methodic recommendations regarding the usage in the educational process to be relevant and promising.

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