Implementing e-learning with personalized trajectories

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Abstract. The article presents the author's approach to building adaptive e-learning courses, an example of the Moodle distance learning system. The introduction of adaptive e-learning courses into the educational process improves the quality of the educational process. The main advantage is the individualization of the educational process for each student. In addition, students' independent work will acquire a directional character with minimal teacher involvement. The developed course allows for statistical processing of learning outcomes and tracking the dynamics students' performance as they study the discipline.

1. Introduction
In the modern environment of higher education, e-learning closely coexists with traditional university educational technologies and harmoniously complements them [1]. The information systems on the basis of which e-learning is implemented are usually called Learning Management Systems (LMS). The widespread LMS Moodle platform is a web site content management system specially designed for the creation of online training courses. Electronic courses developed on the basis of this platform are one of the most accessible forms of presenting educational materials. Often, electronic educational resources based on LMS Moodle implement a sequential structured presentation of the discipline's material (or any subject area), without taking into account the individual characteristics of students' perception of information. However, the results of a number of studies indicate a significant increase in the effectiveness of the educational process when using adaptive electronic educational resources focused on building several educational trajectories within the framework of one discipline or subject area [2, 3]. Requirements are made to the quality and level of complexity of the electronic course, which take into account the level of knowledge of the student at the initial, intermediate and final stages of preparation [4]. Educational trajectories should be formed in accordance with the principles of homogeneity, completeness and consistency of educational content, which allows the use of uniform mechanisms for assessing the degree of mastering of competencies by students [5]. The article highlights the process of creating an adaptive electronic course as a means of organizing and implementing the educational process.

2. Research methods
Adaptive learning is a technological system of forms and methods, contributing to the organization of effective individual educational process [6]. It takes into account the level and structure of the initial readiness of students, promptly monitors their current performance, which makes it possible to rationally select training materials [7]. An adaptive learning system is able to provide each student with assistance to achieve an educational result in accordance with his abilities and capabilities. Despite numerous
publications on topics and problems of adaptive learning, today there is no single formal approach for these tasks [8].

The discipline material was analyzed in order to highlight key concepts and form a vocabulary of the subject area of the course to form individual educational trajectories. As a result, an enlarged hierarchy of concepts was formed, shown in Figure 1. This tree of concepts of the course reflects the basic concepts of technology for designing object-oriented automated systems using the unified modeling language UML. It is necessary to traverse the tree of concepts in depth to study the material, which means studying the material of each vertex of the graph. In this case, each vertex corresponds to three versions of the presentation of the theoretical material, which do not differ in content, but have differences in the type of presentation of the material. The materials may differ when considering training examples, program code designed to solve the same problem, etc. The depth of presentation of each concept may also differ, but the form of presentation (text, video, audio) remains the same for all variants in order to comply with the principle of homogeneity. Each version of the presentation should not contain redundant knowledge in relation to the other version, which allows us to consider them equivalent in terms of the concept disclosure. Thus, the developed electronic course contains 30 different options for presenting theoretical material, corresponding to each top of the discipline's concept tree.

![Figure 1. Tree of discipline concepts.](image)

3. Case study

LMS Moodle is the world's most popular open source learning management system. Moodle offers a huge number of opportunities for creating and storing materials, monitoring the degree of student achievement and organizing communication between participants in the educational process [9]. The flexibility of the system, due to the huge number of settings, makes it possible to adapt it to the specific needs of users [10]. The hierarchy of concepts is reduced to a linear form suitable for implementation in LMS Moodle to create an adaptive e-learning course (Figure 2). Such a structure implements an algorithm for automatic transitions along the branches of the concept tree, depending on the level of assimilation of the acquired knowledge for each of the concepts. The study of the material of each vertex of the concept tree ends with a control point (test). At the beginning of studying the discipline, the student is in the introductory module (corresponds to the top "Object-oriented modeling" in Figure 1) and studies the material in version B1 (Figure 2).

After studying the current material, in order to gain access to the next section (P_N in Figure 2, where N is the number of the corresponding version of the presentation of the material), he should perform introductory testing. The test results are the criterion by which the student either proceeds to study the next module, or studies the topic in another version of the presentation, previously not available (B_2 in Figure 2). Thus, in case of a completely unsuccessful test, you can pass all 3 options for presenting the material of the introductory module, available in the course, but initially hidden from the user. If the
third test attempt fails, a message is displayed about the need for consultation with the teacher, and the main purpose of the consultation is to identify the reasons for unsuccessful testing for subsequent correction or formation of an additional version of the presentation of the material of the term or concept of adaptive e-learning course.

Based on the stated principle of implementing transitions according to the options for presenting theoretical material, the student forms his own educational trajectory, which includes such options for presenting the material, which, based on the test results, contain the amount of material necessary and sufficient to study the corresponding nodal concept of the course tree. At the same time, the bank of test items is the same for each of the sections, regardless of the options for presenting the theoretical materials of the section. This approach guarantees the objectivity of the control of mastering the sections of the course, provided that the equivalence of the options for presenting the materials is observed and the bank of test tasks for the section is sufficient. It is also worth noting that testing is performed for a limited time, the duration of which is related to the number of questions in the test, reflecting the nature and volume of the theoretical material of the section.

In the developed electronic course, all the elements that the student did not pass or did not manage to pass are hidden. When opening the course, the student has access only to the introductory module, which presents the material in a single version of presentation in the form of an element of the "Lecture" type. As the course progresses and the transition between elements, the student is exposed to all the hidden elements of the course. Unlike the student, the teacher has access to a complete toolkit for editing the elements of the electronic course, including setting the conditions for transitions between presentation options, levels of passing tests. The difference between the options for displaying course materials for the student and the teacher allows hiding unused material from the student. This avoids unnecessary detailing, as well as unauthorized student access to course elements that are not part of their own educational trajectory.

The developed electronic course was introduced into the teaching process of the Institute of Space and Information Technologies of the Siberian Federal University. The number of students participating in the approbation of the course - 63, of whom 58.7% completed the course, 30% did not participate, 21.3% did not study the course in full. When analyzing the results, the following were measured: the duration of the study of each term (if the student studied several versions of the presentation, the total duration was measured), the time of passing the test for each term (when retesting, the maximum time was chosen), and the testing and performance of laboratory tasks were assessed.
The obtained statistical data were analyzed for anomalous values to correct technical errors, perform correlation and linear regression analysis. The results of the analysis indicate the presence of a strong connection between the duration of the study of the module and the tests result (Figure 3). There is also a dependence of the estimate for the term on the number of transitions between the versions of the presentation of the material. The results obtained allow concluding about the effectiveness of the e-learning course in terms of streamlining the independent work of students, increasing the efficiency of independent study of theoretical material. The results showed the dependence of the received positive ratings on the duration of studying the course materials and the duration of testing, increasing the objectivity and efficiency of evaluating the results of the educational process.

4. Conclusion
The use of adaptive e-learning courses in the educational process allows personalizing training and increasing its effectiveness. The article describes the construction of an adaptive learning system in an electronic environment, a description of the structure and components of this system, as well as the principles of its design. In our research, we propose an e-learning concept based on the principles of personalization and content variability. The subject area is formalized in the form of a system of basic concepts, which are built in the form of a hierarchical structure as tree of concepts. We propose the original structure of an adaptive learning system in an electronic course. Based on the proposed adaptive learning system, an electronic course was developed that was successfully implemented in the educational process of students. The uses of the developed e-course in the study of the discipline allow students building an individual educational trajectory.

References
[1] Morris B T and Trivedi M M 2011 Trajectory Learning for Activity Understanding: Unsupervised, Multilevel, and Long-Term Adaptive Approach IEEE Transactions on Pattern Analysis and Machine Intelligence 33(11) 2287-301
[2] Kinchuk, Chang M, Graf S and Yang G 2010 Adaptivity and Personalization in Mobile Learning Tech., Inst., Cognition and Learning 8 163-74
[3] Nedungadi P and Raman R 2012 A new approach to personalization : integration e-learning and m-learning Educational Technology Research Dev 60 659-78
[4] Oommen B J , Yazidi A and Granmo O C 2012 An adaptive approach to learning the preferences of users in a social network using weak estimators Journal of Information Processing Systems 8(2) 191-212
[5] Cidral W A , Oliveira T, Felice M D and Apricio M 2018 E-learning success determinants: Brazilian empirical study Computers & Education 122 273-90
[6] Pham L, Limbu Y B, Bui T K, Nguyen H T and Pham H T 2019 Does e-learning service quality influence e-learning student satisfaction and loyalty? Evidence from Vietnam Int J Educ Technol High Educ 16(7)

[7] Fraihat D A, Joy M and Sinclair J 2020 Evaluating E-learning systems success: An empirical study Computers in Human Behavior 102 67-87

[8] Tavangarian D, Leypold M E, Nölting K, Röser M and Voigt D 2004 Is e-Learning the Solution for Individual Learning? Journal of E-learning 2(2) 273-80

[9] Bulaeva M N, Vaganova O I, Koldina M I, Lapshova A V and Khizhnyi A V 2018 Preparation of Bachelors of Professional Training Using MOODLE The Impact of Information on Modern Humans. HOSMC 2017. Advances in Intelligent Systems and Computing 622 406-11

[10] Escobar-Rodriguez T and Monge-Lozano P 2012 The acceptance of Moodle technology by business administration students Computers & Education 58(4) 1085-93