ALGORITHM FOR MODELING AN INDIVIDUAL LEARNING PATH

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Abstract

The paper deals with algorithms for opting for the right learning management system to manage individual students' training by interdisciplinary integration and internal differentiation. The authors offer a graphical model of such a system, transition and connection algorithms designed based on the theory of finite-state machines. The authors also describe the implementation of the system design and the results of introducing the system into the learning process.

Keywords: learning management system, theory of finite-state machines, transition algorithms, connection algorithms, learning automation, individualization of the learning process, and differentiation of the learning process.

1. INTRODUCTION

Having analyzed such documents as the National Doctrine of Education in the Russian Federation 2025, the Law on Education in the Russian Federation (2012), and the Concept of Modernizing Russian Education we have concluded that the humanization strategy will be decisive in reforming the educational sphere. The objective of the strategy is to create an individual educational path of a student, with sufficient training facilities that are crucial for the growth and development of a future specialist.

Russian system of higher education is currently being reformed; it is changing to new standards, thus, new methods, means and technologies such as distance and blended forms of training (Toktarova V.I., 2015), interactive software programs and simulators (Nikitin P.V., Gorokhova R.I., 2014), adaptive and intelligent systems (Toktarova V.I., Panturova A.A., 2015) aiming at improving the quality of education are introduced into the learning process. According to the Decree of the Government of the Russian Federation dated 3, December, 2012 No 2237-r (On approval of the Program of Fundamental Research of the State Academy of Sciences for 2013-2020): "Each university has the right to approve the list of courses of the variable (profile) part within the total workload of the variable part, specified in the federal state educational standards (hereinafter FSES) and a model curriculum. The list of courses of the variable part, is only recommended in the model curriculum provided that the university fosters the competences described in the model basic educational program (BEP) ...". Hence, personal traits of students, their preferences and inclinations should be taken into account in the variable part of the curriculum. This part should include courses selected by the students themselves. In this regard, it is recommended to provide students with as much information as possible, so that they are capable of managing the learning process at any stage. This requires a learning management system that can take into account the preferences of students, recommend them to take a course in accordance with their individual characteristics and the results of knowledge assessment, as well as undertake certain research and present only the necessary information

2. ALGORITHMS FOR DESIGNING EDUCATIONAL PATH

2.1. Analysis of Learning Management Systems

Learning management systems usually serve to monitor a large number of students. Some of them focus on educational institutions, others focus on corporate training. Those systems allow you to monitor the training process of active users, to store their characteristics, to count the number of visits to certain website sections, and to determine the time that a student spends to pass a certain part of a course.

Such systems allow users to enroll in a course. Enrolled students are automatically sent various pieces of information about current events and necessary reporting. Students can be grouped. In addition, there is an opportunity to test knowledge and to communicate online.

The effectiveness of a learning management system is much dependent on the technologies used. The capabilities and characteristics of various learning systems should ensure the maximum interaction between a student and a teacher within the system. The more complicated the software is to use the less willing the students and teacher are to deploy information technologies in the learning and teaching processes.

The software is usually a simple static HTML page, as well as more complex Learning Content Management Systems.

The successful learning management system implementation is generally based on the right choice of software that meets specific requirements.

These requirements are predetermined by the needs of students, teachers and an administrator, who will monitor the installation, configuration of the software and learning outcomes.

There are many learning management systems, such as: Moodle, Blackboard, ConnectEDU, Schoology, Edmodo and others. However, these systems are user-friendly only when students take a certain course, but they become inappropriate when one needs to create individual educational path throughout the entire period of students' learning process, taking into account their individual abilities and the courses they have chosen (Nikitin P.V., Fominyh I.A., Gorokhova R.I., 2015). To better manage individualized learning process based on interdisciplinary integration and internal differentiation, the authors designed an automated environment for creating individual students’ learning paths (ROSPATENT No20103661179), which makes it possible to implement the approach previously described.

2.2. Theory of Finite-State Machines to Model Individual Learning Path

One of the methods of modeling the management system can be the theory of finite-state machine. Individual characteristics, as well as the level of competence acquisition can vary with time. Therefore, the system involves a transition between the levels of assignment complexity, which is based on Mealy finite-state machine.

The Mealy state machine is given by a set of five elements S={A, Z, W, δ, φ}, where:

A = {A0, A1, A2} – is the input alphabet of the machine, corresponding to the value of the result of the initial level of knowledge in a certain area: A0 – the threshold level (70 %), A1 – above the threshold level, A2 – below the threshold level;

Z = {Z0, Z1, Z2, Z3, Zi} – is the output alphabet of the competence acquisition by students: Z0 - competences are not acquired, Z1 - low level of acquisition, Z2 - medium level of acquisition, Z3 - high level of acquisition, Zi - the learner has achieved the research level;

W = {W0, W1, W2, W3, W4, Wi} – is the alphabet of stopping the machine at a certain level of competence acquisition: W0 - initial state, W1 - stop of the machine operation, W2 – assignment complexity for the lower level of competences, W3 - assignment complexity for the average level of competences, W4 - assignment complexity for a higher level of competences, Wi - assignment complexity for the research level of competences;

δ(Wi, Aj) – is the function of transitions between levels of competence acquisition;

φ(Wi, Aj) – is the function of the outputs of the machine and the presentation of the result of the competences acquisition.

The presented sets were used in implementing the Mealy state machine. The state machine gives the level of competence acquisition that will be further used to pass to the next stage of the learning process. Functions δ(Wi, Aj) and φ(Wi, Aj) show the way in the process of creating an individual learning path a decision is made to output the result. The state of the alphabet W1 corresponds to the shutdown of the state machine at a certain level of competence acquisition and outputs the results of the level of competency acquisition of Zi students.

A student is given a set of assignments of a certain level of complexity based on the results of the input testing when the initial state of the W0 state machine is set. When giving assignments of the threshold level of complexity A0, the state machine gives assignments for the average level of competences and thus shows a lower level of competence in the Z1 competence acquisition. The choice of assignments with a level of complexity below the A2 threshold level indicates that the competences are not acquired; at the output, the machine stops in the Z0 state. The Z3 state, indicating the acquisition of a higher level of competences by students is determined when the assignments are selected from above the A1 threshold level and students are able to complete assignments with a higher level of competence complexity. The function of transition between the levels of competence acquisition makes it possible to trace the result of forming a higher level of competences, as well as when students do assignments of the threshold and below the threshold levels. Moreover, the state machine stops at the research level of competence acquisition when students do assignments of the research level or choose the level of assignment complexity above the threshold level.

The model described allows us to optimize the learning process, as the W0 state takes into account the level of assignment complexity and tests the assignments for various levels of competences.

Moore finite-state machine is used to manage transitions between modules of the courses taken, an Internet simulator and a teacher. The given model takes into account the state of the machine at a certain point and thus the transitions between various modules and states are monitored, the formalized model of which is presented in Figure 1.

The input alphabet of the machine represents an integrated indicator corresponding to the level of assignment complexity and the indicator of the learning path (retrospective) A = {A0, A1}. A0 – competences are not acquired, A1 – competences are acquired.

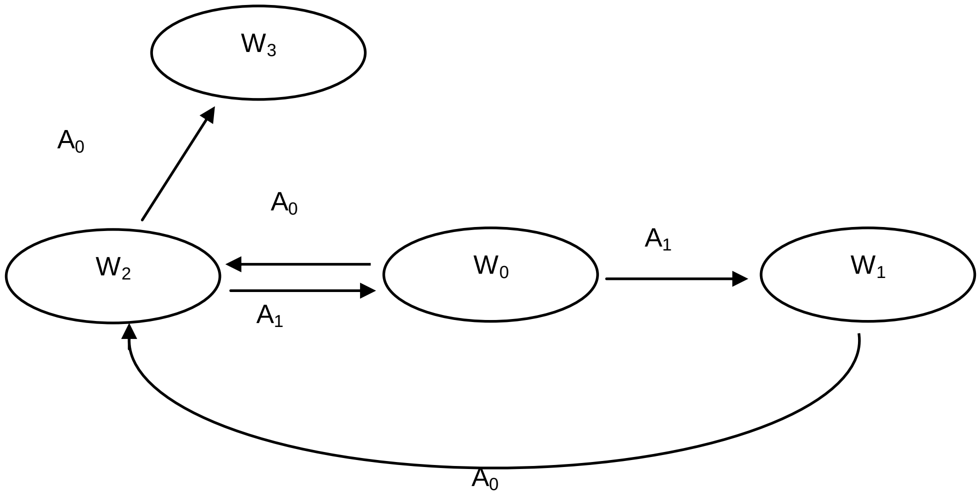

Fig.1. The formalized model of management of transitions between modules of studied disciplines

The output alphabet is dependent only on the state of the system at a given time.

The internal states of the model W = {W0, W1, W2, W3}, determine the transition, where:

W0 – current module;

W1 – next module;

W2 – an Internet simulator;

W3 – to a teacher.

The operation of the machine taking into account the control functions (Fig. 1) are presented in Table 1. The table shows the state of W3 in which the control transition occurs to the instructor. The teacher can reset the machine, complete the course or return the learner to any initial state. The main task of this state is that if the system at an arbitrary stage of training cannot adapt to the trainee (for example, the transition to the block below does not give the proper level of assimilation of the material), then the management or solution of the problem is transferred to the teacher who decides on the further trajectory learning.

Table 1 - Control functions of Moore automaton

Entrance / Output (Status)	A_0	A_1
W_0	W_2	W_1
W_1	W_2	-
W_2	W_3	W_0
W_3	-	-

Mealy and Moore finite-state machines described above are used in the creation of a management system model of learning paths.

At present, the model of the management system of educational trajectories is introduced into the system of training students of the following universities: "Priamursky State University", "Volga State Technological University", "Mari State University", "Interregional Social Institute". The results of the ascertaining experiment (observation, conversation, questioning of students, analysis of educational activity) showed a positive effect of this system on the achievement of the required level of formation of competencies stated in the study of disciplines. The competences of the students were checked at each stage of the study of the material and recorded during the experiment, different results were observed from the Z0 level - competencies were not formed at the initial stage, until the Zi level reached at the final stage of the research. In accordance with this, the complexity of assignments was selected for each level of competence.

Therefore, the model of the educational trajectory management system described above provides the teachers with the opportunity to create a flexible structure for managing students' learning and cognitive activities, to implement a personal-oriented approach, to observe not only the process of developing the knowledge and skills of trainees, but also to monitor the dynamics of this process.

3. RESULTS

The process of implementing an individual learning path can be presented as an information model of the relationship between the main structural units of the learning process. It is recommended to take into account the information-logical connection of the units of the educational material as well as the rules for establishing relations and the standard structures that they form when you create an individual path. The system model is represented as an oriented graph; the vertices correspond to certain structural units of the educational material, and the edges show the relation of order. The order of moving along the educational material in accordance with a certain individual learning path corresponds to the orientation of the edges of the graph, with the help of which the transitions between the vertices are displayed.

Consequently, the intellectual training system gives recommendations for a more thorough study of certain courses, and offers a subject area in a form of electives; the choice of courses is generally based on a model, which is designed by use of a pre-trained neural network (training is built on standard algorithms (Gorokhova R. I., Nikitin P.V., 2012). When a course is taken for the first time, the system will offer a student an initial test to determine the level of knowledge and, based on the results, it will further form a set of assignments, laboratory work and tests. The assignments can be of various complexity depending on the results of student performance. In the case when a course is not new to the student, then the system will take into account the results of the sections of the given subject area that have already been passed, and will form the level of complexity of assignments. The system performs an intermediate control of knowledge and competences acquisition and thus it creates and adjusts the individual learning path. In the case when the results for competences acquisition are “below the threshold” the system will make a student to work with an online simulator, where the student is offered examples of such assignments, with a detailed explanation of the right solution. As soon as all the assignments with the Internet simulator are passed, the system makes a student to retake the interrupted session. If the number of “repeats” is higher than the threshold that the teacher sets in the system, then the teacher has the right to interfere.

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4. RECOMMENDATIONS

To sum up, the designed system allows us to manage individual learning based on interdisciplinary integration and internal differentiation, which will eventually improve the quality of students’ learning experience.

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