The method for developing practice-oriented skills when studying the Control System Modeling course in the e-learning environment

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Abstract. This article presents a model of a subsystem for performing practical tasks of an adaptive electronic learning resource (AELR) in the LMS Moodle environment. The authors consider the distinctive aspects of forming individual educational trajectories for the development of skills and abilities in studying the Control System Modeling course using the LMS Moodle instrumental apparatus. The paper presents an algorithm for developing the skills needed to perform the operations under study. The algorithm suggests step-by-step skill development through frequently repeated actions and gradually complicated tasks with the reducing time allotted for their solving. Further, the paper analyses experimental results concerning the introduction of the adaptive electronic learning resources into the educational process. It was found that higher involvement in the educational process and greater learning efficiency are observed in the experimental student group where the learning process was arranged through an adaptive electronic learning resource, as compared to the control group that participated in traditional classroom activities. It was also found that the application of the learning method using the adaptive electronic learning resources leads to statistically significant (at the level of 95% according to the chi-squared distribution) differences in the learning results.

1. Introduction
The current trend in the development of university educational activities implies the practice-oriented approach to learning. This means creating the conditions for the development of students’ professional, individual and creative potential to form the competencies significant for their future professional activities and ensure they could perform their professional duties properly.

In addition to knowledge, skills and abilities as an integral part of practical activities are the basis for the development and manifestation of the competencies created as a result of a course study.

Moreover, for a modern specialist, it is not so much knowledge that is important as the ability to apply them to solve specific situations and problems that arise in professional activities and in life [1]. Practice-oriented skills are formed and implemented in the process of professionally directed activities [2], they must be considered from the point of view of the most effective use for solving highly specialized problems, building an appropriate educational process for all parties interested in the final result [3].

The term “skills” means the readiness to consciously and independently perform practical and theoretical actions based on acquired knowledge [4]. The skills developed in studying the Control
System Modeling course within the bachelor degree program 27.03.04 “Management in Technical Systems” are as follows: the ability to use mathematical modelling methods in the development of automated and control systems and tools; the ability to apply techniques for processing and presenting experimental data; the ability to carry out experiments with existing facilities and process results using modern information technologies and technical means.

The term “skills” means components of practical activities to be demonstrated when performing necessary actions brought to perfection by frequent repetition [4]. Thus, as a result of studying the Control System Modeling course, students are to acquire fluent skills in mathematical modelling methods and principles, as well as in computational (computer) experiments when creating automated and control systems and tools.

The learning environment implements the practice-oriented approach and entails the introduction of specific adaptive learning technologies into the educational process. These technologies allow students to create an individual trajectory of learning the course as per their educational goals, level of knowledge, psychophysiological qualities, possibilities of comfortable organisation of the educational process, etc.

E-learning environments, such as LMS Moodle [5], are an effective platform for implementing adaptive learning technologies. The authors of [6,7] describe a method for creating an adaptive electronic learning resource (AELR) in the LMS Moodle. Such an AELR enables building an optimal educational trajectory using the electronic environment instrumental apparatus.

LMS Moodle contains built-in tools for both posting educational content and measuring learning results, as well as for navigating the course components when building an individual educational trajectory. A prerequisite for effective AELR functioning is the automated educational trajectory formation using e-learning environment tools. On the one hand, this enables a student to learn the educational material independently, thereby ensuring the transfer of classroom activities to the electronic environment. On the other hand, it frees the teachers from the routines of conducting the classes of the electronic course, thereby providing an opportunity to focus on creating high-quality learning content, regular course update and student counselling.

2. Methods

This article presents the experience of using the personalised learning content for the development of skills and abilities in the Control System Modeling course designed in the LMS Moodle e-learning environment within the framework of an AELR introduced into the eCourses e-learning environment of Siberian Federal University.

Paper [6] describes the basic principles of the AELR practical task subsystem designed to develop student skills and abilities taking into account the initial level of their knowledge, career guidance and learning efficiency with regard to the educational information that, when taken in a separate course unit, includes [7]:

1) a theoretical test to determine a practical task trajectory;
2) a practical task to acquire skills;
3) the task assessment by the teacher who admits the students to the next AELR component;
4) a practical test to acquire stable skills and determine further learning trajectory.

Let us focus on the practical implementation of the practical task subsystem using the LMS Moodle means. The subsystem provides automated navigation between AELR components and forms a unique educational trajectory in studying the Control System Modeling course.

The educational content aimed at skill development is presented in three versions (A, B and C). The type of version available to students corresponds to their unit theoretical test results: type A (brief explanations, when the test result is high), type B (extensive description of the main computer-aided operations for system model construction, including examples of how to perform the tasks, when the test result is medium), type C (excessively detailed explanations including additional examples of how to perform the tasks, when the test result is low).
The components of the AELR practical task subsystem for skill development are implemented in the form of the LMS Moodle “Task” elements and are supported with learning materials, such as:
- methodical instructions on how to perform practical tasks (a PDF file) in versions A, B and C;
- Mathcad, Matlab and GPSS files with the examples of how to perform the tasks (figure 1), available for download in versions B and C. The students following the B and C trajectories have the opportunity to familiarise themselves with a different number of possible examples of system models, algorithms for their functioning, model parameters, calculation parameters, etc.

**Figure 1.** AELR element, Practical Task No. 1 (version C).

This approach ensures an adequate understanding of specific tasks by students with different levels of knowledge and learning speed. Thus, the students, who show high results when studying the theoretical material preceding the practical tasks, are provided with the material of above-average complexity as simple tasks do not have any developing potential. Alternatively, the students with a low level of competence cannot understand the material of an increased complexity, which may finally lead to a decrease in their motivation [7].

Figure 2 shows some examples of practical task access settings used for automatic transitions. If a practical task presented in version C is completed incorrectly, the students are advised to consult their teacher in person.

For some course units, a different scheme was used to organise the practical task AELR subsystem, i.e. an individual educational trajectory was formed depending on the students’ professional interests [6].

Let us note the following necessary conditions for creating an individual trajectory when doing the practical tasks:
- limiting the time allotted for the task;
- performing practical tasks of basic complexity only in all units (with the compulsory studying of the theoretical material) should not allow getting a specified number of points sufficient for the course interim assessment;
- performing the tasks of high complexity can become the basis for preparing a relevant graduate qualification work.
The tests constructed as per the algorithm shown in figure 3 are used to drill the skills of performing the operations under study. The ability to perform these operations has been generally formed at the stage of doing practical tasks. The step-by-step skill development is implemented through frequently repeating actions and gradually complicated tasks with the reducing time allotted for their solving.

For example, to develop the skills related to the computer-based modelling of control systems using various software tools:

1) The students are given a modelling task and the model input parameters in the LMS Moodle “Test” or “Lecture” element.
2) The students do the modelling in the specified software (Mathcad, Matlab, GPSS).
3) As the modelling result, the students find the required output parameters of the model.
4) The resulting output parameters of the model are entered in the LMS Moodle “Test” element as an answer to the question.
5) If the model is constructed correctly, the answer entered by the student will coincide with the one specified in the question as a reference and will automatically open access to the test containing the next skill-training task.
6) The students are given a more extensive task that includes the construction of a more complex model. Now, they have a time limit to do the test.
7) Etc.

The students’ ability to do the tasks with the required speed or faster and pass the time-limited test means that they have developed the corresponding skill, while their attempts to pass the test provide an opportunity to train the skill. Figure 3 shows an algorithm for training skills related to the modelling of queuing systems in Simulink using the SimEvents library blocks (the Matlab system).

The type of tests used for skill training is usually a numeric answer, i.e. the answer is entered as a real number with a given accuracy and error (figure 4 (a)).
Some tasks, mostly those related to problem-solving, are presented in the calculated format, which ensures a variety of initial conditions to reduce the possibility of academic misconduct when performed by the students. For the calculated-type tasks (figure 4 (b)), the task text (in curly brackets) indicates some variables, while the answer field is for the formula linking the variables, an error and the required accuracy display.

3. Results
To assess the effectiveness of the method for developing the students' skills and abilities using AELRs, the authors implemented the method with the evaluation of the following results of the experimental student group studying the course using the AELR and the control group studying in a traditional form with classroom activities: student’s involvement in the learning process, current academic performance, final grade and retained knowledge (figure 5).
4. Discussion
The analysis shows that the student's involvement in the learning process (figure 5 (a)) when using the AELR is higher as compared to the traditional classes. The involvement was assessed based on the timeliness of performing the practical tasks of the course units. At the same time, the academic performance charts presented in figure 5 (b, d) show that the learning efficiency is higher in the case of using the AELR (the experimental and control groups' characteristics before the experiment were close) (figure 5 (c, d)). The statistical significance of similar (figure 5 (c)) and different (figure 5 (d)) group characteristics is confirmed by the $\chi^2$ criterion [8,9] with 95% confidence, which indicates that the effect of changes is due to the application of the learning method of using the AELR to develop the skills and abilities.

The effectiveness of the AELR application in the educational process is explained by an increased student motivation due to an individual trajectory intended to develop his or her skills and adapted to the student's individual qualities and interests. The flexible organisation of practical tasks forms the student's involvement and interest in the learning process, as well as develops his/her independence and responsible attitude towards learning, which positively affects the learning output (figure 5).

5. Conclusion
Thus, being able to form individual educational trajectories in the development of student skills and abilities, the AELRs are an effective means of organising the educational process. This serves as a sufficient basis for using the AELRs in the electronic environment for full-time students and to implement distance and blended learning models.

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