USE OF THE JAVA GRADER AND LAMS INTEGRATION FOR VALIDATION OF STUDENTS PROGRAMMING SKILLS IN PERSONALIZED E-LEARNING PROCESSES

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Abstract: *Personalized e-learning processes require validation of learning outcomes after each learning activity. In case of Java programming courses, validation activities require the use of a Java grader, a software component that checks the syntax and results of students programs developed in validation activities of an e-learning process. This paper demonstrates how a Java grader, developed as an integrated software component of LAMS (Learning Activity Management System) can be used in personalized e-learning processes. A course developer may now choose the Java Grader as a new LAMS activity used for validation of students programming skills, during design of a learning process with branching based on validation results. External Java graders have been used as external plug-in components of Learning Management Systems (LMSs), but in the presented implementation of Java graders, the developed Java Grader is the integrated software component of a LMS (known as LAMS).*

Keywords: *E-learning, personalized learning, Java grader, validation of learning outcomes*

1. INTRODUCTION[1]

In parallel with the development of the Internet areas that are directly related to this type of information exchange have been developed as well. E-learning represents the presents and the future of learning. This type of learning provides opportunities that are not available with traditional lectures (in the classroom). Professor in the traditional way of teaching is a lecturer while in online e-learning he is an author who creates and posts teaching materials visible to users (pupils, students). Authors of teaching materials for distance learning have to attract users and to facilitate interactivity and collaboration between them. The advantage of e-learning is the interactivity that is possible within the system, availability of learning materials at any time, consultation and collaboration between users. [8]

Development of the system for distance learning has enabled the implementation of additional activities in teaching materials. In addition to standard materials, systems for distance learning provide lectures in electronic format (PDF, HTML format), an author has also additional activities that can encourage users to further deepen their knowledge. Author, using e-learning systems, can create lessons with additional content such as questions and answers, colloquium on the system, links to external additional materials. By posting the above content, author improves and enriches teaching material and brings it closer to the traditional way of teaching where the lecturer shows additional examples, asks questions and makes suggestions to students.

The creation of teaching material for distance learning is a complex process as well as the selection of the system for posting it. There is a variety of open-source system for distance learning but this paper will focus on the LAMS system (Learning Activity Management System) [11] that is used within Metropolitan University and the creation of a learning process. This system has the ability to add a large number of activities that can enhance the learning process and improve the interactivity and flexibility of teaching materials.

2. MOTIVATING OF STUDENTS

The biggest identified problem of learning process is to motivate students to go through the learning process. Very often, students take a PDF version of teaching materials without opening the process of learning and passing through interactive content. The LAMS, as a system that supports the creation of a learning process, offers the possibility of creating a defined learning process. One of the proposed ways to improve and increase the number of students using the learning process is to set additional activities. A PDF version of teaching materials is more convenient for students, as they may go through the same many times without conditions as it is the case in LAMS learning process. Additional interaction with students in activities such as questions and answers, additional resources, advices and information on a topic on external sites may increase the desire of students to access and go through the learning process. [7] If the author of the course provides students with interactive

approach in lesson with the types of the final exam questions of the course, where students will check their knowledge in each lesson (the learning process) and have an outline information about their knowledge and possible exam questions, it is possible to increase the number of students using the learning processes. Also, by adding video material (YouTube video, or video from a computer) where students will have an insight into the teaching topic explained in other way with completed demonstration examples that will facilitate homework and preparation for the practical part of the exam it can be achieved greater collaboration with students in the learning processes. The authors of the course may be present in the activities of the learning process and provide additional guidance and advice to students through teaching material. [3]

In courses that deal with programming, the introduction of external graders for the Java programming language, which was developed at the University Metropolitan, and similar activities will present the learning process that does not differ greatly from traditional lectures and exercises where the student in a few seconds can get answer for completed task and continue the path through the learning process. One of the methods may be the LAMS branching activity where students will be able to choose by which learning process want to go through the teaching topic. Author of the course is the one who defines learning objects and activities for each of the available paths. Informing students that, if they have prior knowledge of the teaching topic, they can choose the path (a learning process), which has an advanced level and the increased number of tasks that is needed to students, it can enable a larger number of students who access to learning processes. The described methods may be implemented as a test in one or two subjects in the learning processes that possess the above activities with a constant message to students about the benefits of going through the process of learning (collecting only relevant information, demonstration examples and assignments).

3. PERSONALIZED LEARNING

Personalized way of learning is based on the good quality environment in which learning takes place. This includes LMS (Learning Management System) that supports this way of learning and offers various forms to create the path of the learning process. This type of learning allows students to obtain only that material needed according to their knowledge. Professor is the one who determines the materials that will be available to students depending on their knowledge.

The first thing that should be identified is the level of knowledge that the student possesses at the beginning of the learning process. The second item involves finding teaching materials and author who can provide the required level of knowledge. As already stated, the use of LAMS allows for the use of various activities to check students' knowledge on the basis of which the author of the course can have an insight into the level of knowledge possessed by students. Most often this is resolved by using questions and answers as well as tests after lessons. The results represent data that show the student's level of knowledge and therefore the level to which the teaching

material should be adapted. Author, if necessary, can also use other activities that are available in the system. In accordance with the results obtained through testing of students, two approaches to personalized way of learning can be developed. [6]

The first approach assumes that based on student's answers and activities, the author of the course finds the level where student gravitates through his/her learning. Whether it is about the answers to questions, work on assignments, time spent on specific topics in the learning process, the results are collected and represent the subject of future analysis of the student. Author of the course will have at disposal the relevant information about students on the basis of which it is possible to create adequate levels of a particular course or lecture. [1]

In this approach, a problem that can occur is the inability of the student to refer if he/she notices that the level of knowledge is not adapted to the knowledge previously shown (it may happen that the student shows knowledge in one area while showing the low level of knowledge in another area). If the student notices that it is necessary to increase the level of knowledge in a particular area he/she may contact the professor with the request.

Adaption of learning process to the specific needs and abilities of student in order to optimize student's learning path, requires information on the current state of student's knowledge in the field relevant to the lesson studied by the student, as well as other data relevant to the determination of the further path of student's learning. As the student, and his/her acceptance and mastering new knowledge are decisive influential factor for guidance of learning process during a lesson, it is necessary to create an appropriate **student model** (i.e., user of e-learning system) who will direct the future course of his teaching by his/her behavior and reactions to different kinds of assessment tests during the learning process. The e-learning system adapts next activities of learning and teaching content (by area and level of shown knowledge) taking into account the behavior of the student model in the activities of knowledge verification after each learning activity during the verification of the learning process. In this way, the learning process becomes a **process of personalized learning**, as the next learning activities adapt to the results of the verification activities of the newly acquired knowledge after each learning activity.

The system, based on presented knowledge of student can determine the next learning activity in the learning process. Ideally, generation of new activity with ad-hoc determined optimal content of the next learning activity would be performed at the time of completion of the verification activity of newly acquired knowledge (Figure 1a). However, this way of adaptive personalized e-learning is a very challenging research and development task. It requires fast, ad-hoc configuration of teaching material of the next activity in the learning process, in accordance with ad-hoc determined next task of learning, compatible with the result of previously completed verification of student's knowledge.
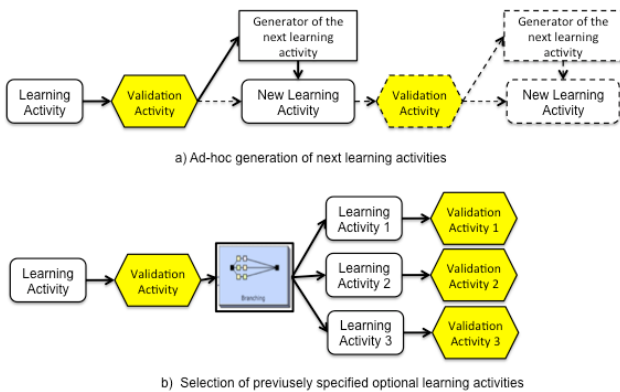
Figure 1. Two approaches to personalized e-learning

This is the direction of a long-term research conducted at the Belgrade Metropolitan University. However, at this point, our research is aimed at achieving more modest objective. We are currently aiming to achieve branching of learning processes after each verification activity of the student's knowledge. His/her learning process is directed towards several options of the next learning activities, which are pre-defined and entered into the system (Figure 1. b). This approach requires from the author of the course to prepare and provide in advance a variety of teaching materials for different, optional learning activities and learning paths, adjusted to pre-defined objectives of each of these activities.

In parallel with the determination of the level of student's knowledge during the learning process within a lesson, it is possible to find students with similar answers and demonstrated knowledge and thus create a **network of students** who can jointly work on specific educational topics and tasks. In this way, it creates a learning process and networks of students with similar levels of demonstrated knowledge. Of course, networks of students can be changed on the basis of lessons and teaching materials accessed by students and it is possible for a student to be in different networks at different educational topics and tasks. Previously described user modeling is performed once a week. If necessary, it is possible to reduce or increase the time limit according to the teaching materials that need to be reviewed. Each student gets a different model based on the previously demonstrated knowledge on teaching subject, while the same case is with the network of students. Also, based on user model, the author of the course can customize future teaching materials and activities to the needs and knowledge of students. [9].

More modest approach to the formation of networks of students is their (just) classification into several groups, formed according to their initial level of knowledge and their ability to acquire new knowledge. Each group has its own path of learning. They can be defined at the course level or at the lesson level [4]. This approach encourages collaboration among students, joint problem solving and emphasizes the development of relations between students acquiring knowledge through group work.

Beginning of introduction of personalized learning involves creating student models. Based on the research, student model is defined based on the behavior of the student during learning, through a review of the activities through which the student has passed (log files), the number of clicks in a lesson, downloading additional material and time spent on specific topics. Creation of a student model often includes available algorithms that goes through the system and collect the necessary information and thus provides the author of the course with an insight into the knowledge of users. In addition to these activities, it is again necessary to mentioned answers to questions during the lesson (function offered by LAMS). The analysis of results of verification of an acquired knowledge enables the teacher or tutor to access and get the necessary information without the use of an algorithm for determination of the user model. For example, the activity of verification "Questions and Answers" offers the possibility to analyze students' answers (through user interface) and possible additional verification of knowledge. (Figure 2).
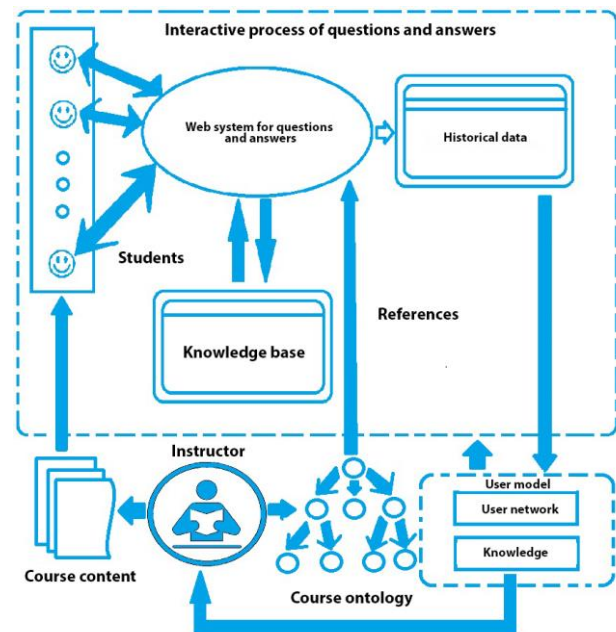

Figure 2. A typical process in a personalized way of learning

1. Structure of course and lessons: It represents the division of material into simple units and determination of the structure of the lesson. Author of the course determines the lessons of the course, as the highest level of grouping of learning activities within a course. Then, the author determines teaching material for certain units that make each lesson. On this basis, it is possible to perform division into levels of learning according to defined structure.

2. Interactive process: Starting from the predefined hierarchy of the course through the LMS system it is possible to create an interactive process in which students will participate. Interactive process enables the system to maintain student activities through the teaching process (answers to questions, most commonly used teaching materials, time spent on teaching materials) and consequently to determine the way of student's learning and his/her activity in the teaching process. If the student spends most of his/her time doing tasks on the system, the system will then provide additional tasks to the student, in order to reach the required level of efficiency in solving

them. Student model remembers, for each student, data on his/her learning process, and on the activities of the process accessed by the student. [4]

3. Student modeling: Student model is created, either for each student individually or for a group of students with similar demonstrated knowledge and capabilities. Student group model approximately represents the average model of students who are part of a group. Using a larger number of groups within a course (subject), group model is closer to the model of each student in the group.

As mentioned, groups of students can be formed at the beginning of the course, based on initial estimates of the level of their knowledge and learning capabilities, or groups are formed in an ad-hoc manner during the learning process of the course, based on demonstrated knowledge of the student during the verification activity of acquired knowledge. Ad-hoc groups of students can be formed on the basis of identification of students with similar answers and demonstrated knowledge and thus creating a network of students who can jointly work on specific educational topics and tasks. This is the way of creation of the learning process and establishment of network of students with similar levels of demonstrated knowledge. Of course, networks of students (i.e., ad-hoc student groups) can be changed on the basis of lessons and teaching materials accessed by students and it is possible for a student to be in different networks at different educational topics and tasks. Previously described user modeling is performed once a week. If necessary, it is possible to reduce or increase the time limit according to the teaching materials that need to be reviewed.

In the case of application of e-learning system with the predefined learning paths for different groups of students (Figure 1b), author of the course for each branch of the process and its activities must provide adequate teaching materials. The system of e-learning of the Metropolitan University, therefore, uses learning objects of small granularity, which can be easier and more often combined to create teaching materials in accordance with the goals of learning activities. This creates a multiple usability (reusability) of learning objects, which reduces the cost and time for preparation of teaching materials.

4. ENVIRONMENTS FOR PERSONALIZED E-LEARNING PROCESSES

The environment in which the student will go through the learning process must be set up so that the focus is on the following components:

- characteristics of the student
- goals to be achieved in teaching and learning
- activities associated with the process of learning
- tasks setting strategies that are used to obtain information about the student's knowledge and determination of path throughout the learning process.

Six basic components are:
1. Characteristics of the student
2. Support in the learning process
3. Skills of the student

4. Content of teaching material
5. Available additional resources
6. Tasks

Each of these basic components has additional subcomponents that represent additional items that make up the learning process. (Figure 3) Depending on the results of students, there are components that will make the learning process while relating to the environment in which learning takes place. Of course, the author should determine the other components in the process based on the components of characteristics and skills of the student. Each level uses the same components and different subcomponents that are available. An example might be an advanced level where it should be post to the student as many different subcomponents of the component „tasks", while at the basic level it is needed to post more educational material to introduce students to the basics of teaching topic, as well as demonstrative examples. Author of the course creates a course by looking from the students' perspective, intelligibility of posted materials and activities included in the learning process. [2]
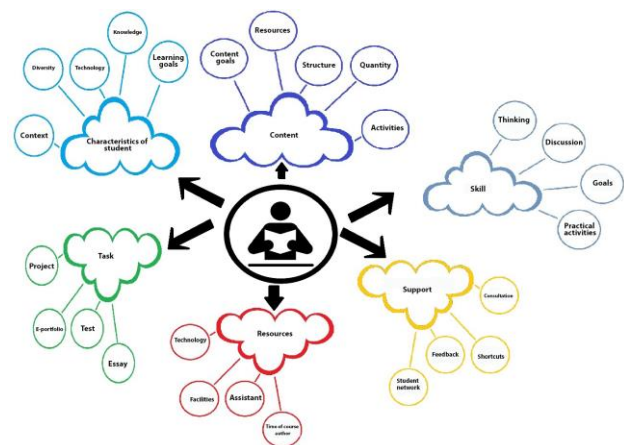

Figure 3. Components of personalized learning process

Personalized learning process allows students to use some of the activities in the teaching process where they will show their knowledge. Usually it is recommended to use questions and answers, where the student can look up the answers from other students if the student thinks that he/she did not answered correctly and in this way they can check and improve their knowledge. It is recommended that the student in the system have the ability to input any perception of a teaching material, whether the student considers that the learning process is too difficult or easy according to the knowledge he/she possesses and activities through which he/she has passed. In this way, the author gets another feedback from the student that can be used in user modeling and preparation of teaching materials for future lessons or for the next generation of students, or to modify the existing process of learning. [5]

Verification activity of acquired knowledge of the student, which usually follows after each learning activity, is usually implemented through different types of tests. For the purpose of efficiency, it is preferred to use automated tests, which for each student generate different questions from predefined set of possible questions and on the basis of obtained answer the system immediately

provides the test result showing the wrong and correct answers to the student. However, in the case of the use of tests with open responses, that is, in which the student enters textually his/her answer, an automated evaluation is not possible, and then it has to be done by tutors, that is, trained staff who monitor and evaluate the performance of each student.

Application of tests is not suitable for all subjects, or is not sufficient for evaluation of achieved level of knowledge and skills in certain disciplines. In these cases, it is necessary to develop and implement specific methodologies of automated evaluation of students, which are not based on the answers in the tests, but on an assessment of the student's problem solving. The next chapter provides the way of evaluating programming skills of students, which was developed at the Metropolitan University.

5. THE JAVA GRADER FOR LAMS

Programming courses and application development at the Belgrade Metropolitan University require homework assignments and tasks to practice within the Java development environment (NetBeans, Eclipse). Students submit their homework reports to their tutors or professors for review, who must take the received files and re-open through the development environment and run programs developed by students. This type of work is very time-consuming for tutors who review each home work of each student.

The external grader for the Java programming language (Java External Grader) enables simpler process of making tasks for practice and even some homework. It was developed as a LAMS activity that can be set in the context of the learning process (sequence) without additional posting links and going to other sites. Student performs programming tasks in Java directly in LAMS, and evaluation of his work gets immediately after the posted task is done (as information from the system). Teacher or tutor may subsequently access and check the answers given by students. The system automatically checks the entered programming code and as a result prints to the student whether the entered answer is in accordance with the desired response to the question. This will largely shorten the time required for the creation and verification of tasks for practice and homework (student accesses to the task for practice, where he receives the text of the task and then realizes it in a development environment) and therefore teachers and tutors can spend their time to quality making of the learning processes and objects in them. This type of external grader does not exist in other open source LMS systems for distance learning but it is necessary to implement integration with some existing software. [10]

Using external grader and through its additional improvement (introducing more classes, developing testing of multiple methods), course authors can create a learning process that will allow students to do their whole homework on the system without the needed development environment and earn all the points directly on the LAMS (without additional systems, accessing and sending e-mails). Safety of the external grader depends directly on the LAMS. The created user accounts and defined user roles in the LAMS apply for the external grader as well. User with a specific role in the LAMS gets only options provided for this user role. Also, students have access only to their answers and it is not possible to see other students' answers on activities. This approach allows safe doing of tasks and storage of information entered by students. Unauthorized access to information shall be registered by the LAMS and it is possible to find such a user account and to suspend it.

A problem that has not been resolved concerns the opening of other files and environments besides the LAMS. In this way the student can open the document or find a solution on the Internet and copy it as the answer. Another way of misuse means that the same student accesses from different user accounts and solves quests. This problem generally occurs in all systems that do not have the solved testing process of students where the student sees a window with questions without the possibility of opening new pages in the browser or files from his/her computer.

Systems for distance learning do not support the verification of the program code but students are required to submit solutions to professors or teaching assistants in file format from the development environment. By implementing an external grader, the role of the professor refers to the creation of the task and eventually checking the answers. Students can independently do tasks and check their solutions according to the parameters without the help of the professor or teaching assistant. Also, the professor can define homework that the student may do directly without additional development environment. The aim of this software is to improve learning processes at the Metropolitan University, to provide additional content that has not been available in subjects dealing with programming in the Java programming language and to improve the experience of students in working with LAMS. This has improved the function of LAMS as a system for e-learning with additional options that are available to the authors of the course. Also, observing the other available activities that can be entered as part of the learning process (sequence) administrative part related to the external grader is much smaller, simpler and more intuitive.

The primary idea of external grader of the Java program for LAMS is to allow verification of the Java program code directly in the LAMS. Author of the course defines one or more tasks according to the needs of the creating test. Each task consists of:

- text of the task
- entered solution in the form of a method of the Java programming language that is checked by the system
- parameters based on which the system checks the answers
- expected results according to set parameters

An activity of the external grader may contain one or more tasks. Tasks are presented within one page in the order defined by the author. The order of the task can be changed after creating all tasks. When the author has set the specified verification activity within the lesson, the student accesses to the activity and enters his/her solution of the task in the form of method. The student gets feedback whether he correctly entered the method (the correct syntax). Once the student has received

confirmation that the method is correctly written, the system prints whether the answer meets all parameters which verify the correct answer in the method. If the results of the entered method with defined parameters print the result that has been specified previously, the student has done the task correctly. If at least one of the results is not met, the entered solution is not correct. The student can leave partially completed solution and in the accordance with the response to be evaluated or continue the path throughout the learning process.

After selection of activities, the test is shown to the student. The left side shows a learning process which in this case contains only one activity while the right side shows the tasks. The user enters his solution of the task in the form of a method of the Java programming language.
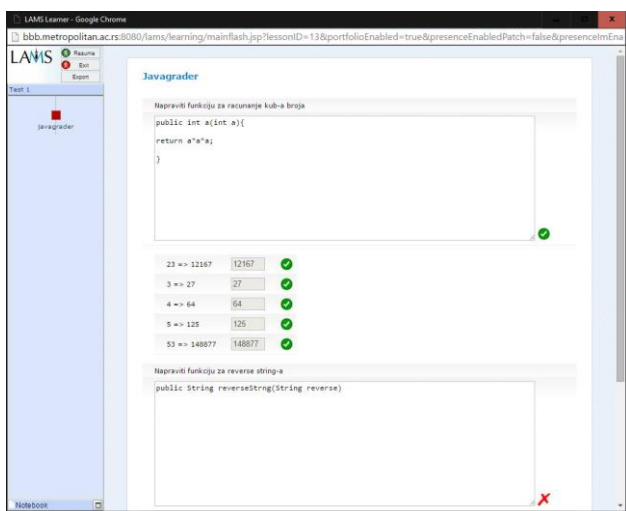

Figure 4. Validation of the answer in the external grader

The student has correctly answered the question and the system displayed information that the entered method is syntactically correct and that the parameters entered in the method of the student correspond to the expected results in the task. (Figure 4)
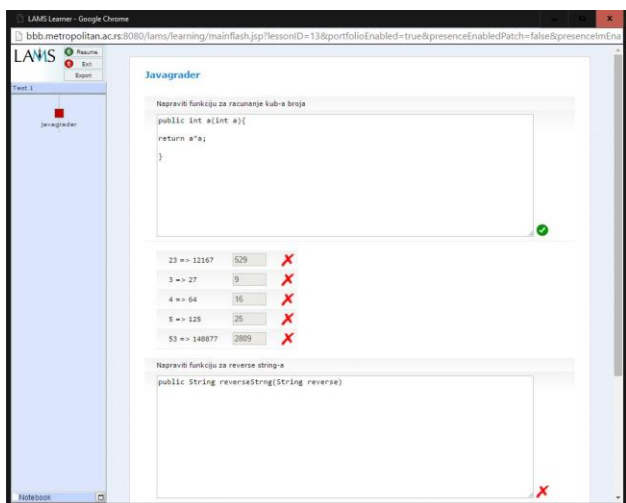

Figure 5. Method entry and syntax validation

Figure 5 shows the case when the student enters the syntactically correct method of the Java programming language and gets information that the method is correct but the results do not match, which means that it is not a method that is required for an answer and the student must modify the method to meet the expected results.

Student can answer each question in the test but also he can answer only one question. Also, it is possible to enter parts of the method that may show that the student has some knowledge in the work but he failed to complete the task. After completing the test, student by clicking the "Next activity" button moves to the next activity and in this case he ends the entire learning process.

6. PROBLEMS OF PERSONALIZATION OF LEARNING PROCESSES

Adaptability of the learning process and proper sequencing of learning activities is one of the potential problems. Problems often appear in teaching materials, where knowledge levels are not properly defined by the author as well as the overloading of material and the inability to reuse it. If the teaching material is written for only one level, it can not be used in personalized learning processes beyond that level. The problem occurs when the system needs to create different personalized learning processes for defined topic. The system performs a search of the teaching material and if there is no learning object that fits the student model for which the system creates the learning process, the system will not create and display a learning process. [6]

Most of personalized learning system is based on control by the tutor (professor). If the professor does not create properly teaching material that is entered into the system, does not determine the levels of teaching materials and does not provide appropriate tasks to check the student's knowledge systems can not create an appropriate learning process and student model. Also, another problem that arises is reflected in the undergoing of students through personalized learning process. If the student using the navigation and a few clicks in the system goes through the learning process without staying at the teaching material, the system can get bad information and create a student model. In this case, the system displays the more advanced t learning process to the student impairing the student model which can be corrected by collecting information from the next learning process or through intervention of tutor.

Systems do not have a solution for solving the problem of semantic adaptability and personalization. Also, the system for personalized learning should address pedagogical aspect of learning. The analysis shows that in the traditional way of teaching a student asks 0.1 question within an hour, while on the system for e-learning, student can require a response (or ask) to about 120 questions within an hour.

In the accordance with the above analysis, it is necessary to create teaching materials and set learning processes so that the student has the answer or explanation at every moment during the teaching process. If this is not possible, re-engagement of teachers in the learning process is necessary.

Adaptive learning systems can be used as support for online e-learning or as additions to systems for e-learning.

Implementation challenges are more operational than technological. From the technological point of view, it is possible to create a system and determine criteria according which the system will display teaching materials. On the operational side, disadvantages that appear are related to the situation when students progress at different steps. It may be that a student in one part of the personalized learning process achieves a great progress while in the second part there is a drop, so it is up to the system to provide accurate personalized learning process according to the demonstrated knowledge.

System used for personalized learning processes must have clearly defined answers to the students. If a student goes through a learning process, takes test or answers questions, after the activity he has to receive feedback from the system. Feedback shows the student whether he answered correctly to a given activity and any deficiencies that may occur. Also, when moving to another level of the learning process, the system must notify the student. In this way, the student will always know his position in the learning process and properly determine the speed and course of his learning.

Solution of the problem of implementing the concept of personalized learning can be achieved defining teaching strategy in the system, the professor through his engagement can predict possible problems and solve them within learning processes, define additional activities that will represent the results of the student's work in the learning process. Personalized learning process is based on the constant improvement of teaching materials, collaboration with students and the system, as well as through the validation of student models.

7. CONCLUSION

Student models are needed to implement personalized e-learning. But, to provide needed data for student models, validation of their learning is necessary. Validation of learning outcomes after each of learning activity, may provide branching of learning paths in a learning process model of an online lesson. Based of achieved validation results, students follow different learning paths. When students learn programming, validation activities should use automating graders of their programs. In this paper, a newly developed Java Grader was used as an integrated software component of LAMS [11]. With this, LAMS now may offer e new LAMS activity that validates students programs written in Java. Based on the validation results, different braches of a learning processes may be specified and different learning paths may be designed. LAMS will guide students to different learning paths based on validation of their programming skills, when the developed Java Grader is used for validation as a new LAMS activity.

Teaching material structured as learning objects of fine granularity is necessary to support personalized learning processes. BMU has developed a large number of small learning objects with fine granularity used in learning activities of learning processes. Each designed online lesson may have a complex learning process with branching, after each validation activity [4]. Validation of Java programming skills of students is now possible with the developed Java Grader, now offered as a new LAMS

activity. This is one of the steps necessary for development of personalized e-learning processes in online programming courses.

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