Development of interactive tools for intelligent engineering education system

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Abstract. Increasing the students' motivation for learning is related to the effective management of the student's development process, which requires the skills of conducting an active dialogue, organizing communication methods, jointly searching for solutions by an educator. The main methodological innovations of this direction are connected with the use of interactive learning methods, which help an educator and student to interact.

Keywords: Learning management system, Moodle, Interactive learning tools.

1 Introduction

Increasing the students' motivation for learning is related to the effective management of the student's development process, which requires the skills of conducting an active dialogue, organizing communication methods, jointly searching for solutions by an educator.

The main methodological innovations of this direction are connected with the use of interactive learning methods, which help an educator and student to interact.

The goal of this research work is to improve the quality of education which is based on the active use of e-Learning and distance technologies through the interactive learning tools development in Moodle LMS.

2 Problem

The goal of this research work is to improve the quality of education which is based on the active use of e-Learning and distance technologies through the interactive learning tools development in Moodle LMS.

In order to achieve this goal, we had to solve the following tasks.

1. The "Student's identification" project was developed in order to allow Moodle to identify an Internet user during the final testing of a discipline. The essence of the project is that the browser working with Moodle takes pictures of a user and enters them into the statistics of the discipline's e-learning system, and an educator gets this statistic.

2. The "Rating of educational material's sections in the network course" service was developed. The rating is formed on the basis of student's reviews and comments, which allows educators to identify sections with a decreasing rating and sections with an increasing rating. Comments and evaluations of course elements are reflected in a summary table with fields called "course element", "average score», and "number of evaluations".
3. New types of interactive question tests were developed: a) drag and drop onto image questions; b) drag and drop markers questions. This type of a test question allows a student to mark certain areas on the image using special markers; c) drag and drop into text questions; d) the "Setsplitting" questions allow an educator to create questions, in which a student can split elements in groups; e) matching questions, f) short answer questions.
4. The "Practical test work" project was developed. It offers students to develop a test task for the learned material. There are three question types: a short answer from the keyboard; a multiple choice question; a matching question.
5. The "Automated point-rating system (PRS)" project was developed, which contributes to: a) improving the quality of the learning process by inuring the skills and abilities of systematic, rhythmic, independent work during the whole period of study; b) increasing the students' motivation for mastering educational programs by means of a higher differentiation of the evaluation of their current work, as well as raising the level of the educational process organization in the university; c) the implementation of a quality management system that allows educators to quickly optimize the organization of students' independent work on the basis of an analysis of the students' performance indicators, and to timely eliminate shortcomings in mastering and consolidating the learning materials; d) obtaining an objective and more accurate assessment of the knowledge and level of students' professional training in the learning process.

3 Models of e-learning in a modern technical university

The most promising direction of the educational process organization is the distance educational technologies development in all forms of the university's education. In this case, the general principles of constructing the traditional educational process remain. As the distance educational technologies are introduced, the requirements for the quality of educational materials and the provision of training sessions and examinations with educational eContent are sharply increased.

The search and implementation of new opportunities are related to the following models implemented in our university: a) training with Web-based technologies (Web-based learning takes up to 30% time in this model); b) blended training (traditional learning and e-Learning mutually complement each other; the educator's workload is reduced; the need for classrooms in the university is reduced; the efficiency of the educator's work is increased); c) online learning (almost the whole educational process (90-100%) is over Internet. It is characterized by high interactivity of educational content). Bachelor's degree programs are realized using Web-based technologies and

blended training; master's degree programs use blended and online training; online learning is mainly realized in part-time education programs and additional education.

3.1 Development of expert system

To use in Virtual world, we create an expert system. In order to analyze trainee's actions, an ES was developed. It is a separate service that receives a record of trainee's actions, analyzes it and makes the necessary recommendations [6-16].

The analysis of data is based on the production model of knowledge with a direct inference. This model allows us to present knowledge as the following type of sentences: "IF condition, THEN action1, OTHERWISE action2". The expert systems of the production type include a rule's (knowledge's) base, working memory and a rule's interpreter (solver) that implements a certain technique of logical inference. The direct inference realizes the strategy "from facts to conclusions".

Rules for a virtual workplace of a radio fitter are given as:

1. IF "$!REG.RW$ ", THEN "You inserted the operation panel into the wrong connector of the special voltage pad".

2. IF "($SCREW.POT_1$ ||$SCREW.POT_2$) && (! $REG.RW_R$)", THEN "You did not connect the optical cable before adjustment".

3. IF "($SCREW.POT_1$ ||$SCREW.POT_2$) && ($!LB.LBO$), THEN" You did not connect the load panel up before adjustment ".

4. IF "($SCREW.POT_1$ ||$SCREW.POT_2$) && ($!DIV$)", THEN "You did not set the divider before adjustment".

5. IF "($SCREW.POT_1$ ||$SCREW.POT_2$) && ($!V.VO$)", THEN "You did not switch on the voltmeter before adjustment".

6. IF "($SCREW.POT_1$ ||$SCREW.POT_2$) && ($!V.VS$)", THEN "You did not connect the voltmeter up before adjustment".

7. IF "($SCREW.POT_1$ ||$SCREW.POT_2$.) && ($!LB.LBO$)", THEN "You did not switch on the operation panel before adjustment".

A virtual industrial environment was designed and developed on basis of the OpenSim and Unity-3D platforms.

The ES structure is shown in Fig. 1. The ES has a "Rule's editor" web interface for making, editing, deleting and checking rules.

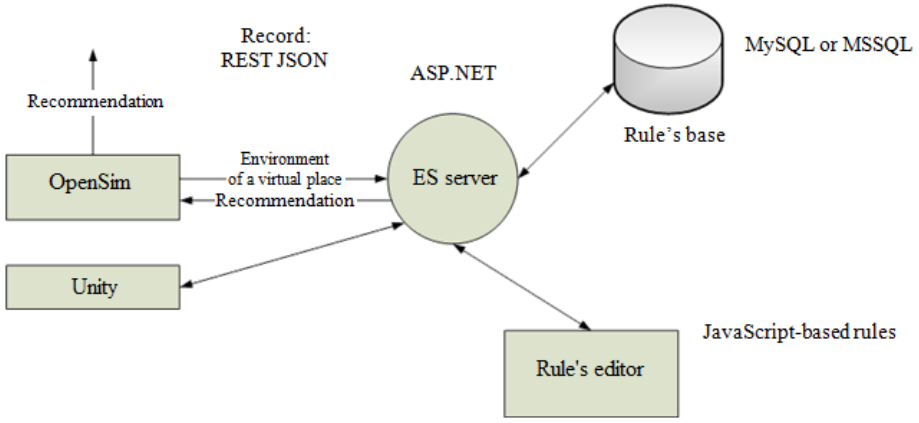

Fig. 1. The structure of the expert system.

A report of trainers' actions is generated during the work with the simulator. It consists of the current state of the simulator, the object with which a student interacted, and the type of interaction. The REST JSON-based report is sent to the ES server. The received data are analyzed via "Rule's base" module's rule, then a message with a list of recommendations is formed.

Below it is described an example of the ES operation. Let us assume that a student inserted the operation panel into the wrong connector when adjusting the radio electronic equipment. The JSON state object passed by the expert system is given as:

```
{
"object":"50",
"action":"click",
"context":"adjuster",
"state":
{
"OperationPanelFork":
        {"rightParent":false},
    "VoltmeterFork":
        {"rightParent":true},
    "CableToLoadUnit":
        {"greenWire":false},
    "CableIntoCheckUnit":
        {"redWire":false},
    "kVC":
        {"blueWire":false},
    "kVZ":
        {"yellowWire":false},
    "PlaceForTheDivider":
        {"Divider":false}
      ...
```

```
    }
}
```

After processing the request and searching for the erroneously inserted parameter, the following message will be sent: "You inserted the operation panel into the wrong connector of the special voltage pad".

4 Interactivity is an objective need for an online course

Today it becomes obvious that it is necessary to manage the student's development process, which means a priority in the educator's work for a dialogue, methods of communication, a joint search for solutions, various creative activities. The main methodological innovations are connected with the use of interactive teaching methods facilitating the interaction between educators and students. The essence of interactive learning is the students' involvement in the cognitive process, during which students have the opportunity to understand and reflect on what they know and think. In the process of joint activity, students make their special individual contribution, at the same time there is an exchange of knowledge, ideas, and activity methods. It allows students to obtain new knowledge and develop cognitive activity. Indeed, interactive forms of conducting classes arouse interest among students, encourage the active participation of everyone in the learning process, contribute to the effective mastering of educational materials, form opinions and attitudes of a student; form life skills, and modify their behavior. Modern pedagogy highlights interactive teaching forms such as creative tasks, work in small groups, educational games, use of public resources, social projects; studying and consolidating new material; testing; discussion of issues; solving problems; trainings. The basis of interactive approaches is interactive exercises and tasks that are performed by students. The main difference between interactive exercises and tasks is that they are aimed not only at consolidating the earlier learned educational material, but also on learning a new one. Training based on interactive educational technologies involves the new experience formation of the theoretical comprehension through application.

In [1], interactive learning methods (ILMs) allow students to intensify the understanding, mastering and creative application of knowledge in performing practical tasks. ILMs increase motivation and involvement of participants in solving the discussed problems. ILMs form the ability to justify one's positions, develop the ability to listen to a different point of view. ILMs allow one to get new experience of activity; the use of ILMs makes it possible to control the mastering of knowledge and the ability to apply the acquired knowledge, abilities and skills in different situations more flexible and humane.

5 Creative developments for Moodle

We have identified the need for user identification based on the analysis of opportunities for testing knowledge in the Moodle environment. The known methods for identifying the Internet user (browser identification; the use of biometric indicators; image matching) have become the basis for our university's project "Moodle-Browser Client". The project identifies the Internet user during the final testing of a discipline. The essence of the project is that the browser while working with the system takes photos of a user/student, the photo is entered into the statistics report of the passed discipline in an e-learning system (ELS). The statistics report is given to an educator.

The project requires the educator's participation in the identification process, but we have identified the benefits of implementing the project: the conditions for recognizing learning outcomes and constructing an individual learning path are realized. The project was tested by part-time and full-time students (more than 160 students).

The use of Moodle's resources for the organization of training in separate academic disciplines in the UlSTU with the use of distance educational technologies implies the evaluation of the service for the organization of automatic subscription to courses, the creation of conditions for studying a particular course and obtaining statistics with grades for performed tests (assignments) and workshops. The service is designed for university's full-time and part-time students wishing to study a separate academic discipline using distance educational technologies. It is also recommended to university's students wishing to make up academic deficiencies upon graduation from academic leave; when coming back to the university for continuing education; when changing the profile of training, specialty, the form of education within the university; when enrolling for a second higher education (including parallel education); when transferring from other universities.

In order to improve the learning materials contained in the individual (separate) materials of the network course, the "Rating of the educational material's sections in the network course" service was developed. The rating is formed on the basis of student's reviews and comments, which allows educators to identify sections with a decreasing rating (in the future these sections should be edited) and sections with an increasing rating (these sections can vary based on comments). Comments and evaluations of the course elements are reflected in the summary table with the fields called course's element, average score, and the number of evaluations.

The new types of interactive tests that we use in Moodle are: a) drag and drop onto image questions (this type of question allows educators to create test questions in which a student drags words, images or both of them from a list and drop them into pre-defined gaps on a base image); b) drag and drop markers questions (markers are dragged onto an area on a background image, this type of question allows a student to mark certain areas on an image using special markers, which can be either one or several); c) drag and drop into text questions (this type of question allows a student to create fields in the text that indicate a missed word or phrase, and at the same time create replies, in the form of blocks with words or phrases that can fill in blanks with drag and drop); d) type of question "Setsplitting" allows an educator to create questions in which a student can split elements in several groups (from 2 to 5); e) matching questions (matching

questions have a content area and a list of names or statements which must be correctly matched against another list of names or statements); e) short answer question. In a short answer question, the student types in a word or phrase in response to a question (that may include an image). Answers may or may not be case sensitive. The answer could be a word or a phrase, but it must match one of your acceptable answers exactly. It's a good idea to keep the required answer as short as possible to avoid missing a correct answer that's phrased differently.

The creative ideas of Knowledge Relative Assessment System by H. Bekker's method served as the basis for testing "Practical test work" (a new toolkit). It asks students to develop a test for the learned material by themselves. There are three templates: a short answer from the keyboard; a multiple-choice question; a compliance test. The developed test is sent for the educator's assessment. If the evaluation is positive, the test is automatically added to the general question bank concerned with a specific topic of a discipline.

6 The automated point-rating system

The introduced automated point-rating system (PRS) contributes to: a) improving the quality of the learning process through the implementation of skills and abilities of systematic, rhythmic, independent work during the whole period of learning; b) increasing the students' motivation for mastering educational programs by means of a higher differentiation of the evaluation of their current educational work, as well as raising the level of the educational process organization in the university; c) implementing a quality management system of education that allows students to quickly optimize the organization of students' independent work on the basis of analyzing the students' progress indicators, and to timely eliminate shortcomings in mastering and consolidating the discipline's material; d) obtaining an objective and more accurate evaluation of knowledge and level of students' professional training in the learning process.

The assessment of students' progress within the PRS is based on points of theme tests, boundary tests and posttests. The discipline's final grade is determined by the sum of the points received by a student for theme tests, boundary tests, posttests, and an exam or a final test.

7 Integration of Moodle with interactive services

Increased research interest is the integration with virtual worlds, representing a 3D virtual environment, where users acquire avatar's appearances and properties (their graphical representation). For example, the virtual platform vAcademia [2] represents services for conducting and attending training courses, meetings, presentations, trainings. The use of Web 2.0 technologies in combination with the capabilities of the virtual world, which allows educators to create interactive educational content. Users can communicate and interact with each other in the virtual world through chat and also voice with the help of a microphone or video conferencing. Within the research, the IDDO ULSTU staff developed a prototype of a virtual classroom based on the tools [4] such

as educational whiteboards with a set of tools and educator and student's workplaces. The classroom allows a student's monitor screen to be displayed with the output of a running application or video from a student's webcam.

Integration with the ePortfolio [3] and with our university's developments allows students to realize his/her portfolio of achievements where a student can accumulate individual, educational, creative and personal achievements. The ePortfolio of achievements is an approval of the educational progress and professional growth.

The use of website's services opens new interactive features [5], due to which educators, tutors, and others can develop interactive applications quickly, and post them on the website with a link to the developed application. The service also allows authors to create interactive crosswords, tests with text input (the application allows authors/educators to create tasks in which a student has to give a verbal answer to the question); closed tests; tasks with audio/video content (the application allows educators/authors to organize the work of students with video files, insert tasks into the videos, instructions, focus on certain details); tasks like "find on a map" (using the application you can develop tasks in which students have to determine the location of various objects on a map), etc.

8 Virtual intelligent training worlds

One of the effective forms of engineering training is the development and use of virtual and additional reality. The use of virtual worlds for acquisition of certain skills and competences increases an effectiveness of training through the maximum approximation to real conditions, from both the point of the objective environment's view and possible actions.

We have developed the virtual workplaces for radio assemblers, adjusters and fitters; the mathematical models of these workplaces are offered, including a composition and description of the permitted actions. The software for the said virtual workplaces has been developed on basis of the UNITY platform. Intellectualization of virtual worlds is connected with the developed expert system (ES) for trainee's actions assessment. This ES knowledge base is founded on the production rules. The direct logical inference is used to issue the recommendations to a trainee.

These virtual workplaces have been embedded into the corporate training environment of a company which is one of the Ulyanovsk State Technical University's (UlSTU's) partners, and are used to upgrade its employees' skills.

These virtual workplaces are also widely used by the UlSTU for students' training in both bachelor's degree program and secondary vocational training program in "Radio-engineering systems and complexes". Students and postgraduates of the Information Systems and Technologies Faculty of the UlSTU are involved to the development of the virtual workplaces' software and 3D models.

The conducted pedagogical experiment demonstrates that the use of intelligent virtual workplaces has sufficiently favored to improve a quality and effectiveness of training in fitting, assembly and adjustment of the radio electronic equipment, as well as to reduce the total period of training by 20-30% and to increase the trainees' motivation.

9 Structure of Virtual industrial world

The virtual world is understood as a simulated environment, "populated" by users communicating with each other through "avatars" – graphic characters. In the industrial virtual world, the organization's production processes are modeled.

Virtual industrial worlds can be represented as a set of special technologies that simulate the tools of real workplaces, the nomenclature of components and accompanying documents and intended for use in both enterprises and universities.

For the expert system's (ES's) operation, it is necessary to develop workplace's models, simulators of which are used in a virtual industrial environment, and analyze the actions that will be an object of a research in the ES.

The logical-algebraic models of workplaces presented in a virtual industrial environment and using the ES as a module of the action's evaluation are developed and described below.

Conclusion and future works

The search for new opportunities and their expansion helps to improve the educator-student interaction by immersing oneself in the problem field of tasks, consistency in the choice of means and methods for the learning tasks performance. The further researches will be focused on including novelty in the learning process, based on the peculiarities of the dynamics of life and activity's development, the specificity of various learning technologies and the individual's needs, and also the need to implement professional standards requirements. It is necessary to emphasize that there is a need to develop mechanisms and procedures for automated assessment of competences (including Moodle's tools) in the run-up to the federal state educational standard of the fourth generation. The use of virtual industrial worlds facilitates increasing the effectiveness of training and reducing the cost of expendables. Virtual workplaces are designed taking into account the scalability of the virtual system and the requirements for technological processes. The conducted pedagogical experiment demonstrates that the use of intelligent virtual workplaces has sufficiently favored to improve a quality and effectiveness of training in fitting, assembly and adjustment of the radio electronic equipment, as well as to reduce the total period of training by 20-30% and to increase the trainees' motivation.

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References

1. Panina, T.: Modern methods for activating education: The textbook. Moscow: Academy (2009).

2. Panyukova, S., Gostin, A., Kuliyeva, G.: Development of a student's web-portfolio: methodical recommendations: The textbook. Ryazan: Ryazan State Radio Engineering University (2013).
3. Virtual Academia. http://www.vacademia.com/, last accessed 2018/03/15.
4. SDK Peasantry. http://www.krestianstvo.org/books/doc/sdk2tutorial/ru/index.html, last accessed 2018/03/15.
5. LearningApps.org. http://learningapps.org/about.php, last accessed 2018/03/15.
6. Afanasyev, A., Voit, N., Voevodin, E., Egorova, T., Novikova, O.: Methods and tools for the development, implementation and use of the intelligent distance learning environment. 8th International Technology, Education and Development Conference: INTED-2014, 3120-3124 (2014).
7. Afanasyev, A., Voit, N., Egorova, T., Novikova, O.: Intelligent learning environments. 9th International Technology, Education and Development Conference: INTED-2015, 4493-4502 (2015).
8. Afanasyev, A.N., Voit, N.N.: Intelligent learning environments for corporations. 9th IEEE International conference on Application of Information and Communication Technologies: AICT – 2015, 107-112 (2015). doi: 10.1109/icaict.2015.7338527.
9. Afanasyev, A., Voit, N., Kanev, D., Afanaseva, T.: Organization, development and implementation of intelligent learning environments. 10th International Technology, Education and Development Conference: INTED-2016, 2232-2242. (2016). doi: 10.21125/inted.2016.1470.
10. Afanasyev, A.N., Voit, N.N., Kanev, D.S.: Development of intelligent learning system based on the ontological approach. 10th IEEE International Conference on Application of Information and Communication Technologies (AICT), 690-694 (2016). doi: 10.1109/ICAICT.2016.7991794.
11. Afanasyev, A., Voit, N., Kanev, D.: Intelligent and virtual training environment. Proceedings of International conference on Fuzzy Logic and Intelligent Technologies in Nuclear Science - FLINS2016, 246-251 (2016). doi: 10.1142/9789813146976_0041.
12. Afanasyev, A., Voit, N., Kanev, D., Afanasyeva, T.: Development and Use of a Virtual Laboratory of Measuring Devices. ICL2017 – 20th International Conference on Interactive Collaborative Learning, 890-897 (2017). URL: http://www.icl-conference.org/icl2017/proceedings.php
13. Afanasyev, A., Voit, N., Ionova, I., Ukhanova, M., Yepifanov, V.: Development of the Intelligent System of Engineering Education for Corporate Use in the University and Enterprises. ICL2017 – 20th International Conference on Interactive Collaborative Learning, 878-889 (2017).
14. Afanasyev, A.N., Voit, N.N., Kanev, D.S.: Development of expert systems for evaluating user's actions in training systems and virtual laboratories. 2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT), 297-300 (2017).
15. Voit, N.N., Afanasyev, A.N., Gulshin, V.A., Bochkov, S.I.: Design of the industrial virtual worlds based on the Opensim platform. 2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT), 301-304 (2017).
16. Afanasyev, A., Afanasyeva, T., Voit, N., Ionova, I., Ukhanova, M.: UNIVERSITY - ENTERPRISE INTELLIGENT CORPORATE TRAINING SYSTEM. EDULEARN17, 5355-5365. doi: 10.21125/edulearn.2017.2209, https://library.iated.org/view/AFANASYEV2017UNI, last accessed 2018/03/15.