Digital Services for Open E-Learning Quality Assurance

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Abstract

The article considers the ideas embodied in the project “Development of infrastructure and means of methodological support for personnel reinforcement of digital transformation of transport and integration into the global transport space”, planned for implementation under the Digital Economy of the Russian Federation program, the departmental project Digital Transport and Logistics.

Introduction

In the next 3 to 5 years, the digital transformation of economics will demand the creation of open education platforms for specialized e-learning. These platforms will allow their users to get quick access to training of quality in the rapidly changing area of new technology. One of these platforms created in 2015 and called Open Education, offers on-line courses in basic subjects taught at universities across Russia.

The most important requirement posed to the open learning platforms is the quality of training they provide.

To satisfy this requirement we propose that a number of digital services be supported by an online course platform, including the following:

1. Virtual Labs
2. Online proctoring
3. Service for searching courses in the database of electronic educational resources of the open learning platform by the content and (or) the level of acquired knowledge and skills
4. Learning Analytics
5. E-learning courses update
6. E-learning courses quality assessment
7. Individual learning path

1 Virtual Labs

By a Virtual Lab (VL), we mean a collection of digital tools supporting remote access to either equipment, such as devices or hardware and software complexes, or to its computer and physical models.

For instance, during a workshop in information technology, the object of study, such as system software or application software, is hosted on a dedicated server and used by students in the shared remote access mode. While ensuring an adequate level of security and priority of access rights, users (trainees) have the opportunity to work out practical skills directly from their workplace in client-server mode. Standard application network services (telnet, rlogin) are usually used as a client to access the training object. However, in some cases specialized client applications may be needed.

It is important to note that in a virtual laboratory, the possibility of independent simultaneous execution of tasks related to setting up, transforming, and reconfiguring a learning object (real equipment model, information system, etc.) should be provided. This is achieved by creating the necessary number of virtual

machines or containers on the lab's server.
As an example, consider the structure of the software package of the virtual laboratory using IBM technologies related to the use of the mainframe System z. Figure 1 shows the structure of the virtual laboratory complex, which includes two main subsystems:

- Learning server System z;
- Web server VL.

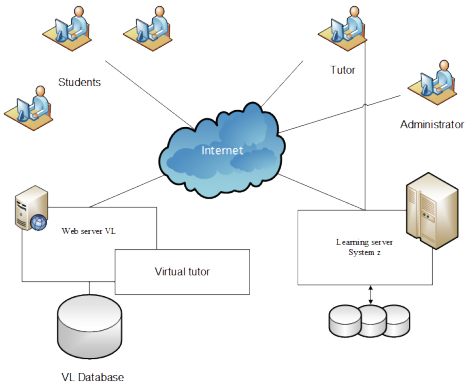

Figure 1. Virtual laboratory complex

Learning server IBM System z is used to perform practical tasks in the multi-user access mode and includes standard purchased software, which, as a rule, is the subject of study.
The web server of the virtual laboratory complex is aimed at the information support of the workshop and serves to collect and display individual results of assignments.
The web server of the virtual laboratory includes a database, as well as a software module for automating the verification of the results of tasks performed («virtual tutor»). Web server deployed on a dedicated server running the operating system Windows or Linux.
The virtual lab clients use a web browser (for example, Google Chrome) to access the virtual laboratory's Web server, and a 3270 terminal emulation program (for example, IBM Personal Communications) for user access to the System z mainframe.
One of the most important principles for building virtual laboratories is the widespread use of virtual machine technology.
Thus, in order to ensure the conduct of a workshop in various disciplines, a multi-system environment based on the use of computer resource partitioning technology into logical partitions (LPAR) and virtual machines is implemented in the mode of multi-user authorized access on the mainframe (figure – 2).
For the needs of the virtual laboratory, there are two logical sections System z (the third section is fixed for solving the problems of the corporate university system).
The logical partition with the educational version of z/OS (LPAR1) is designed to perform exercises that imply the possibility of collective user access to system resources. z/OS has a typical configuration. Users (trainees) should have access to the TSO/ISPF tools, UNIX service, SDSF, as well as have the rights to create and manipulate their own data sets and UNIX files, run batch jobs. The teacher, in addition, needs ftp access support for automated control of the results of assignments.

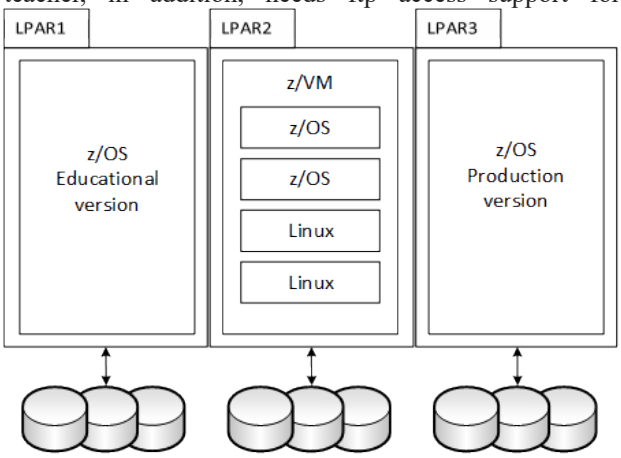

Figure 2. IBM System z Multisystem architecture

The LPAR2 logical partition runs on the z/VM operating system, which allows you to create up to several dozen virtual machines. On virtual machines, the z/OS and Linux operating systems are installed as a guest. This configuration, in particular, provides independent access and use of z/OS resources for multiple users simultaneously. In this case, each user can have an unlimited set of rights within his virtual machine and the copy of the operating system installed on it. This scheme allows one to perform exercises on the administration of operating systems and system software, up to the initial boot, reboot and shutdown of the system, as well as management of performance, security, network services, virtual devices and the like.
A most important stage in conducting practical classes is the stage of control associated with the verification of the results of the student's independent work and the grading. This task is assigned to the teacher accompanying the training course. There are two ways to control: manual and automated. With the traditional manual method, the learner, based on the results of the work performed, draws up a report and sends it to the teacher for verification. Obviously, such a procedure is not very technological and "fits" poorly with the concept of e-learning.
In the context of open learning, the method of automated control proposed by the authors, which can be called "virtual tutor" [1], is of interest [Let07]. We are talking about the development of a special application that monitors the actions of users when working with a learning object, keeps track of the individual results of the implementation of planned practical tasks and automatically generates a test record. Moreover, if the learning object is located on a remote server, the control program is placed directly on the teacher's workstation, gaining access to the file system and journal information of the remote server using standard network protocols. If the installation of the studied software is performed on the user's workstations, then the monitoring of the progress of the tasks is carried out by a special embedded

agent program, which records the results of execution and transfers them to the teacher via the network.
It should be noted that for each educational object not only a different version of the implementation of a virtual tutor is required, but the degree of automation of control operations may also be different. The fact is that not in all cases it is possible to strictly formalize both the tasks themselves and the verification procedures. This means that a real teacher will not remain without work either.
This technology is applied in RUT (MIIT) for the teaching of operation systems (z/OS, UNIX, Linux, IBM DB2 and Oracle).

2 Online proctoring

With the development of e-learning and distance learning technologies, education goes beyond the boundaries of educational institutions. At the same time, one of the most important issues ensuring the quality of education during remote interaction is the verification of self-certification of trainees. A whole class of software products and services that implement online proctoring functions (that is, remote video monitoring of certification measures) has appeared. Among the world and Russian solutions in the field of proctoring are the following:

- ProctorExam;
- ProctorU;
- Examus;
- ProctorEdu.

This service is necessary for students to receive a certificate. In essence, it provides the following instruments.

- verification of the person being certified (based on an identity document or biometric authentication);
- monitoring the certified in real time and automatic video analysis of assessment, aimed at confirming the independence of the certification.

The functional of the service is aimed at detecting the following typical violations when passing certification:

- switched the active test window to a third-party application or browser tab;
- no face in front of the camera for a certain time;
- unauthorized persons in front of the camera;
- microphone mute or low volume, as well as conversation or background noise (audio tips);
- unidentified person in front of the camera (personality substitution).

In addition to the above violations during certification, the service can be used to collect educational analytics in terms of identifying the issues that caused the longest response time.
The presented proctoring technology is implemented in the learning management system RUT [Bug15]. Certification video records are automatically analyzed using machine learning models, potential violations are identified and solutions are prepared for the teacher who checks the independence of the certification process.
A feature of this solution is the use of a webcam installed on the computer being certified, with the following characteristics:

- webcam with a matrix of at least 0.3 MP;
- video resolution not less than 640x480.

3 Service for searching courses in the database of electronic educational resources of the open learning platform by the content and (or) the level of acquired knowledge and skills

A large number of electronic educational resources invariably gives rise to the problem of choosing the most effective way of teaching a particular student, taking into account his existing skills.
The service is based on the use of descriptions of e-learing courses contained in the database of electronic educational resources of the platform, including indications of the prerequisite levels of knowledge and skills, as well as expected learning outcomes.

4 Learning Analytics

The service is based on collecting and analyzing data on the course of user training for each of the electronic courses contained in the database of educational resources of the platform. Data on the course of training also includes information:

- time spent by the user to study each section of the course;
- the number of correct and erroneous answers (to questions related to each section of the course) allowed by the user during certification.

Based on these data, estimates of indicators characterizing the complexity of understanding the sections of the course are formed. These assessments can then be used to improve the quality of the course.

5 E-learning courses update

Progress in the field of information technology has now become so rapid that automating the process of maintaining the relevance of the electronic educational resource base has become an important and necessary task. The release of new software versions, the emergence of new technologies and their introduction into production requires prompt reflection in educational materials.
To solve the problem of maintaining up-to-date electronic educational resources database, it is planned to create a service that analyzes user requests in order to identify keywords that are not contained in the descriptions of electronic courses contained in the electronic educational resources database. In addition, it is planned to assess the relevance of responses to user requests to the database of electronic educational resources by analyzing user behavior (for example, by identifying repeated questions with a modified set of keywords), as well as by collecting user opinions on the conformity of system responses to requests.

6 E-learning courses quality assessment

The service is designed to assess the methodological component of the quality of electronic courses (clarity of the text, quality of structure, interactivity, use of sound, video clips, etc.).

An electronic course (EC) is a means of acquiring knowledge in distance learning systems, using information technology (IT) to deliver content, organize communication with a tutor, and also to enhance the effect of understanding the material and acquiring knowledge and skills. The quality of the EC is defined as a set of properties that contribute to the acquisition of knowledge and skills by the student [Kos10].

To assess the quality of EC, it is proposed to use a system of indicators, which is divided into two groups:

– indicators of methodological properties of the course;

– indicators of technical properties of the course.

Indicators of methodological properties include the following:

– indicators of text quality;

– quality indicators of the student's knowledge control system;

– indicators of sufficiency of use of IT capabilities;

– indicators of course structure;

– indicators of the relevance and the accuracy of the content.

The technical properties are evaluated using such indicators as:

– the indicator of compliance with the requirements of GOST R ISO / IEC 12119-20 00 standards and the availability indicators of each slide xtd;

– the indicator of contrast between the background and text.

The value of each of these indicators depends on the characteristics of the EC. Consider the composition of the characteristics that determine the value of the methodological component of the quality of EC.

The quality of text materials is determined by the following characteristics:

– readability; calculated based on data such as:
  – the proportion of compound words that consist of more than 4 syllables;
  – the proportion of short sentences (less than 13 words);
  – Flesh's text readability rate;
– literacy; estimated based on data such as
  – the proportion of grammatical errors in a unit of text volume;
  – the proportion of spelling errors in a unit of text volume;
– clarity:
  – the proportion of ambiguous sentences (evaluated by an expert);
  – the use of abbreviations in the text, synonyms of special terms (in relation to the total number of special terms);
– the proportion of uncoordinated sentences;

– the proportion of the number of special terms not included in the glossary.

The quality of the student's knowledge control system is determined by the following characteristics of the EC:

– the size of the pool of questions;

– diversity score;

– indicator of the ratio of types of questions.

Indicators of sufficiency of use of IT opportunities are:

– the share of slides with illustrations, animation, videos;

– the share of slides with interactive graphics (of the total number of slides with graphic materials);

– the proportion of interactive simulations;

– the share of simulations and videos with sound.

Structural indicators:

– an introductory section;

– glossary;

– the availability of glossary search;

– the presence of intermediate testing (after each section of the course);

– the proportion of sections of the course with no demonstration examples;

– the ratio of the sections with no interactive simulations to the total number of sections aimed at imparting skills.

The idea of constructing an integral quality assessment of EC is as follows: first, primary indicators are evaluated (automatically or by experts), then estimates of elements of subgroups are calculated from estimates of primary indicators, then an assessment of groups of methodological and technical characteristics is formed in the form of a weighted sum of estimates of elements of subgroups, and, finally, integral quality characteristic of the course (in the form of a weighted sum of evaluations of groups of methodological and technical characteristics).

Suppose, for example, there is a generalized assessment of the methodological characteristics of the course, and - an assessment of textual materials, - an assessment of the knowledge control system, - an assessment of the

adequacy of using graphic and interactive tools, - an assessment of the structure.

According to the above, we require that the value of each of the estimates be in the range from 0 to 1.

Then it is necessary that the values of the coefficients can be found in the following way. We will suggest to experts (students and teachers) on a five-point scale to give a generalized assessment of the methodological characteristics of the courses with known assessments of individual factors (that is, with known ones).

We use the least squares method to find estimates of model parameters.

The result of the calculations depends on the values of weights. The weights are determined by expert. The values of the weights are normalized so that their sum is always equal to one. Provided that the values of the original characteristics of EC vary in the range from zero to one, the rationing of weighting factors leads to the fact that the quality indicator of EC also varies in the range from zero to one. This fact makes it possible to establish a threshold value for the quality indicator when making a decision on accepting a course.

A software package has been developed by RUT to automate the process of assessing methodological quality [Kos13, Let16].

7 Individual learning path

Because of the increase in the number of competencies required for a modern specialist, and the emergence of a large number of open educational resources, there is an acute problem of choosing the optimal individual educational trajectory (ie, the sequence of disciplines studied), which reduces time to achieve the required skills. This problem can be formalized as a problem of minimizing the length of the educational trajectory. Naturally, one would strive to achieve the desired learning outcomes at the lowest cost (in the case of open learning, this means shortest time). Provided that the time spent on studying any course is the same, the number of courses forming this trajectory should be taken as a criterion for the optimality of the learning path.

The initial data for solving this problem are the initial levels of the professional skills of the user (the student), as well as the desired levels of skills after training. The construction of an individual trajectory is carried out by choosing the sequence of studied disciplines (electronic courses) from the base of electronic educational resources. At the same time, it is necessary that each e-course be described by a set of values describing the prerequisites, that one has to possess to master the course materials, as well as a set of values reflecting learning outcomes.

The service allows one to build a sequence of studied disciplines of the smallest length, ensuring the achievement of the required levels of competence for each user [Let15].

Conclusion

The above services are planned to be implemented on a specialized platform of open online training in the field of digital transport and logistics. In addition to the means of supporting these services, the platform should include a Distance Learning System (DLS) with standard functionality (see, for example, [Hus14]), as well as a set of electronic educational resources for training in the field of digital transport and logistics (e-courses, virtual laboratories). According to the plan, the platform will provide the opportunity to conduct training based on distance learning technologies in the following forms:

– individual self-study in individual disciplines (or a combination of disciplines) without conducting certification activities;

– individual self-study in individual disciplines (a set of disciplines) or in professional retraining programs with attestation and certification;

– guided training in groups of professional retraining programs with certification.

The implementation of the educational process in these forms will require the development of a set of regulatory documents establishing the procedure for providing educational services to users.

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